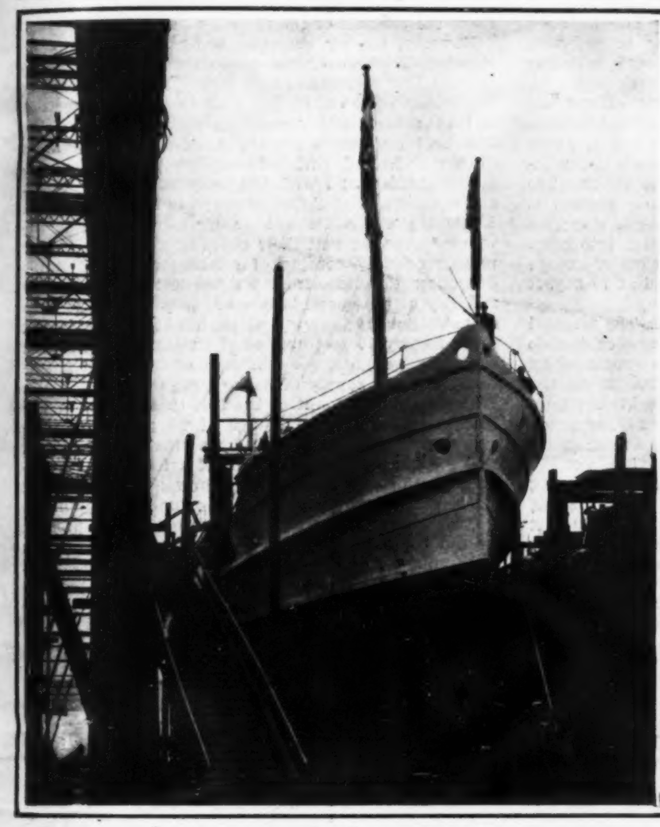
SCIENTIFIC AMERICAN SUPPLEMENT. No. 1621

Entered at the Post Office of New York, N. Y., as Second Class Matter. Copyright, 1907 by Munn & Co.

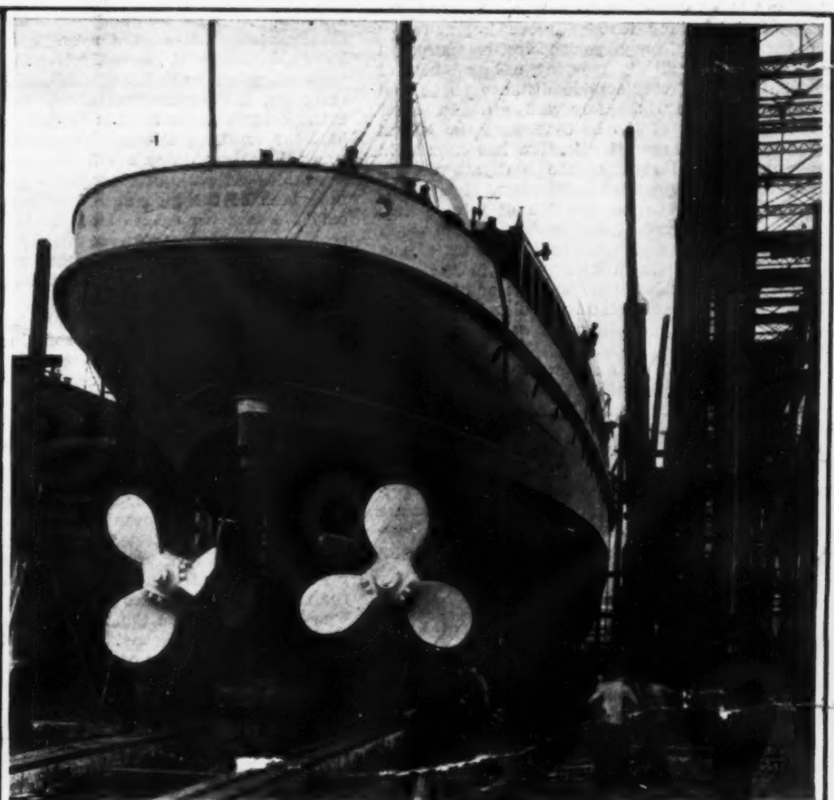
Scientific American, established 1845.
Scientific American Supplement, Vol. LXIII., No. 1621.

NEW YORK, JANUARY 26, 1907.

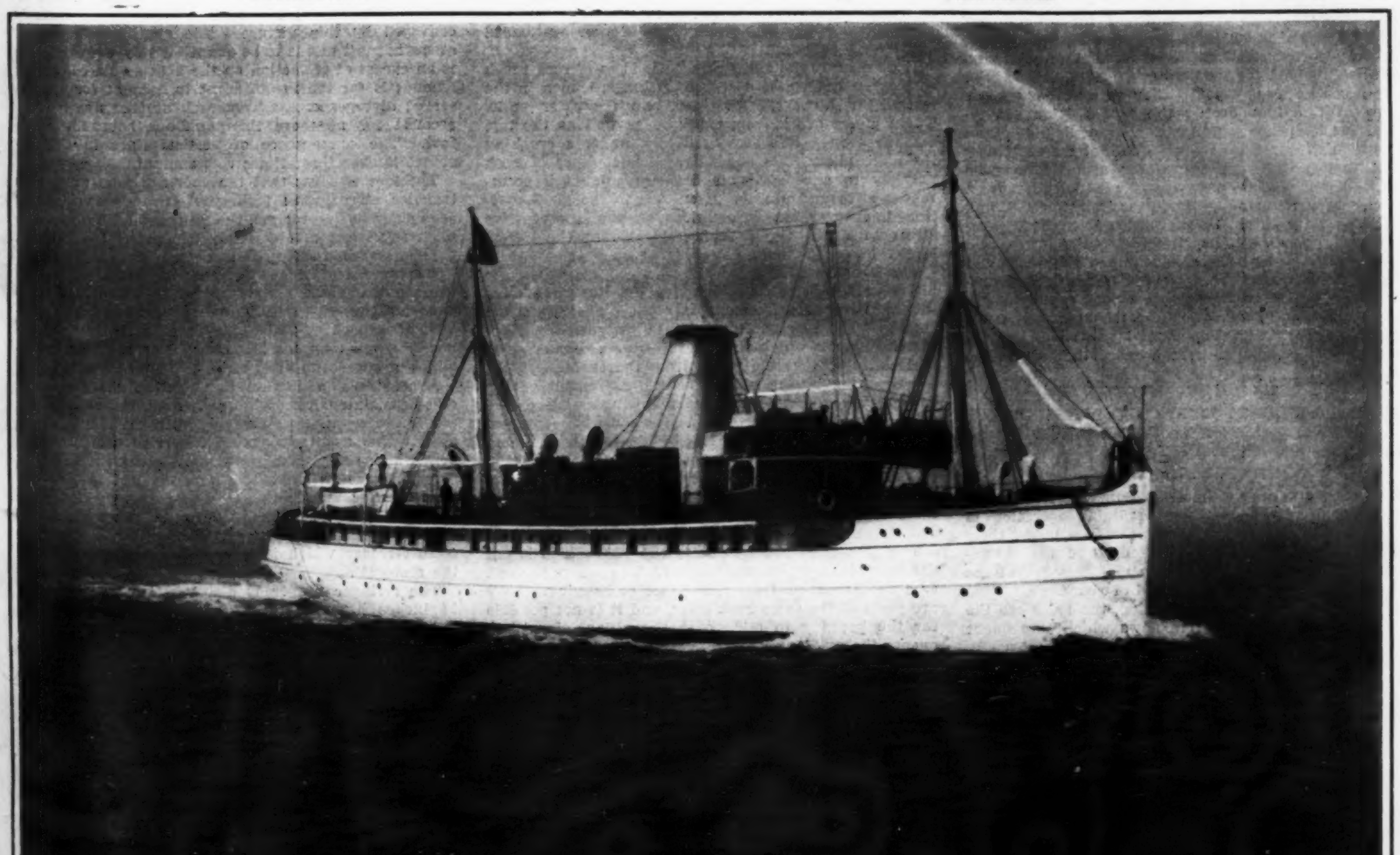
Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.



BOW VIEW OF THE "LADY GREY," SHOWING THE ICE-BREAKING CONSTRUCTION.



STERN VIEW, SHOWING THE LINES OF THE HULL AND THE BUILT-UP PROPELLERS.



THE "LADY GREY" READY TO GO INTO COMMISSION.

COMBINED ICE-BREAKING, SALVAGE, AND SUPPLY STEAMER FOR THE CANADIAN GOVERNMENT.

COMBINED ICE-BREAKING, SALVAGE, AND SURVEY STEAMER FOR THE CANADIAN GOVERNMENT.

By the English Correspondent of SCIENTIFIC AMERICAN.

THE Canadian government has recently acquired an interesting type of ice-breaking steamer, the "Lady Grey," for service upon the St. Lawrence River, for the purpose of maintaining an open navigable channel to the sea during the winter months. The vessel, which has been constructed by Messrs. Vickers, Sons & Maxim, Limited, of Barrow-in-Furness, is of special form and is built with unusually heavy scantlings. The craft measures 172 feet in length between perpendiculars; molded breadth, 32 feet; depth, 18 feet; normal draft, 12 feet; draft when engaged in ice-breaking, 13 feet; displacement, 1,055 tons; indicated horse-power, 2,300; speed, 14 knots per hour.

The bow, as may be seen from the accompanying illustration, is of the Canadian type, designed for mounting and breaking through green ice, and also for forcing its way through pack ice. Great strength is assured to the hull by carrying a broad belt of heavy plating for a considerable distance above and below the waterline right fore and aft. In order to overcome nipping of the hull, through the lateral pressure of the ice, special attention has been paid to the cross-sectional form of the boat, athwartship pressure being additionally counteracted by double framing, formed by the introduction of intermediate channels. Right forward at the point where the vessel first strikes the ice these additional members extend from the keel to the main deck, while in the after section they are fitted between the bilge and the main deck. Moreover, the side plating is also increased in thickness from the stem to a point well aft of amidships.

The hull is divided into six water-tight compartments, while there is a double bottom extending from the forward to the after-peak bulkheads. The compartments forward and aft of these bulkheads are arranged to serve as deep ballast tanks, for the purpose of varying quickly the trim of the vessel, in order to assist it in riding up on the ice to permit the superimposed weight to break up the ice. These tanks are connected by means of a large diameter pipe to powerful ballast pumps, so that the water can be quickly discharged from one into the other as required.

The propelling machinery comprises two sets of inverted vertical direct-acting triple-expansion surface-condensing engines developing 2,300 indicated horse-power when running at 130 revolutions per minute. The high-pressure cylinders are of 19 inches diameter, the intermediate cylinders 30 inches, and the low-pressure cylinders 50 inches; the stroke in all cases being the same—27 inches. Steam is raised in a battery of four single-ended cylindrical boilers 10 feet 6 inches in length by 12 feet 9 inches in diameter, and steam is supplied at a working pressure of 180 pounds per square inch. The furnaces are fired by means of the Jones mechanical underfeed system, with fans for the air supply. The propellers, of which there are two sets provided, are three-bladed and of the built-up type. One set is specially designed for ice-breaking work, while the other is reserved for summer use.

A notable feature of the craft is that although essentially intended for ice-breaking service, it has been so designed as to be capable of fulfilling other equally important functions during the period it is not required for its primary purpose. Powerful pumps and other requisite gear are supplied, so that the craft may be utilized for salvage operations; also she may be employed for towing purposes, for which the great engine power renders the craft admirably suited, and special gear for this class of service is carried. Furthermore, the boat is to be employed by the Marine and Fisheries Board for survey work upon the coast and the channels in navigable waters. For this occupation the vessel is provided with a very complete outfit and ample accommodation for the staff and crew. A complete electric lighting plant is installed, and the equipment is completed with a searchlight of 16,000 candle-power.

SOME PROBLEMS CONNECTED WITH DEEP MINING IN THE LAKE SUPERIOR COPPER DISTRICT.*

By F. W. MCNAIR.

THE copper mines of the Lake Superior district are essentially low grade. Their profitable operation is made possible by the great extent of the lodes, their comparative uniformity of character and the investment of great sums of money to maintain operations on a vast scale over a long period of years.

With but one important exception, the lodes are the vesicular tops of ancient lava flows which subsequent to solidification have had the cavities wholly or partly filled by the deposition of various minerals, among which is native copper. They dip at angles varying from 38 deg. to 70 deg.

The modern shafts through which the rock is hoisted are either inclined, following the plane of the lode, or are vertical. The inclined shafts are of dimensions such as to provide for two railroads of approximately standard gage on which run the "skips" which are operated in balance. In addition there is room for the ladder way and air pipes, usually placed at one side. The vertical shafts have compartments providing usually for "cages" and pipe and ladder way. Several of the inclined shafts are over 5,000 feet long. One has a length of 8,100 feet. Of the vertical shafts the three deepest are, respectively, about 5,200, 5,000, and 4,900 feet deep.

Long before such depths were actually reached there arose the question as to a possible limit set by the ultimate crushing strength of the rock which is penetrated. Manifestly, mining cannot go to a depth such that the weight on walls of drifts and stopes will exceed the ultimate strength of the material of which they are composed. There is a widespread impression that the lake mines are approaching such a limit. There are current statements to the effect that pieces of rock occasionally snap off the rock faces because of the great strain, and are violently projected as if propelled by an explosion.

In this connection a few figures will be of interest. The average density of the rock of the copper-bearing series is not far from 2.87, that is, a cubic foot weighs about 179.3 pounds. Therefore, a horizontal square foot of area at 5,000 feet from the surface has above it a column of rock weighing 448 tons. The ultimate crushing strength of the average rock is not well known, but since it is mostly trap this may be safely assumed as at least 1,200 tons per square foot. If, therefore, the square foot above defined carries the entire column above it, it is loaded to much less than half the crushing strength and only at nearly three times the assumed depth will the load reach its crushing limit. At a dip of 38 deg., the pressure normal to the plane of the lode at 5,000 feet from surface is only 354 tons per square foot. It is in this direction that the crushing forces are mostly called into play. As the dip increases this normal pressure of course diminishes. At 52 deg. it is 278 tons, and at 70 deg. it is 152 tons per square foot.

However, the matter does not end here. The removal of large portions of the copper zone leaves considerable areas of the roof or hanging wall to be supported by the pillars which are left for the purpose, or by the walls of the opening, or by both. The weight on pillars and walls is thus increased and may easily approach the crushing limit. Take, for example, a long pillar 50 feet wide having on either side an open space of 150 feet. Suppose it in a lode dipping 38 deg. Allowing for neither rigidity nor arching, and supposing the weight on the pillar evenly distributed, at 5,000 feet deep it would be subjected to a pressure of 1,239 tons per square foot, a pressure under which it would fail.

As a matter of fact, in such a case the rigidity of the rock mass distributes a large part of the load out over the rock beyond the walls of the opening. That this rigidity may be considerable is illustrated in several cases where areas of hanging as wide as 200 feet or more have no support between walls, and yet have stood up for several years. They are not, however, at maximum depth.

In such an area a pillar when first cut out may have to carry but little more than its previous load. As the hanging wall slowly bends the pillar must take up more and more of the extra weight. This is not applied uniformly. As the rock between pillars and walls bends downward the tendency is to concentrate the load at the edge or face of the pillar, or wall, much as a beam does when supported in like manner. The outer parts of the pillar may thus become overloaded and here it will fail.

It does so by the splitting off of pieces of rock much as may sometimes be observed with a specimen in the testing machine, though on a much greater scale. These pieces break from the base as well as the top, and, as a rule, like any hard rock under a crushing load, the pillar fails suddenly. Small pieces of rock may fly to a considerable distance, and such occurrences have undoubtedly given rise to the above-mentioned exaggerated impression of the compressive stress to which the rock is subjected in the lowest levels.

The hanging rock mass moves, of course, when the pillar crushes, and the vibration due to the sudden though slight displacement is often conveyed to the surface. The result is a miniature but perfectly genuine earthquake which may be felt over a distance several times that of the pillar from the surface. With the crushing of the pillar and the movement of the hanging a readjustment of the weight takes place, and the process begins over again. Instead of the process being repeated exactly it is possible for the hanging to break in such a manner that the arching effect may protect this pillar, and place the load on others. Eventually, at great depths the hanging and foot must come together, and in one mine the final steps in the process came so rapidly as to completely wreck it.

The pressure normal to the plane of the lode is not the only action which may appear. The pillars are not, as a rule, separate from either foot or hanging. They are parts of the same rock mass, and it is not possible for the hanging to slide over the pillar. In consequence the readjustments which take place when a pillar fails as above described sometimes put an enormous longitudinal thrust on the foot, and in places its surface portion has buckled up under such stress. Also, at points where shaft pillars have been weak, shafts have been pinched and twisted under the same conditions so as to interfere with their operation.

Experience seems to have shown that at the great depths recently reached it is useless to expect to hold up the hanging rock mass for a long time by any scheme of pillars unless far too much of the lode is left in place, and that the only feasible method is to cut away the entire lode and permit the hanging to cave as rapidly as it will to the point where the broken rock fills again the whole space, and redistributes the weight over the footwall. Following this plan, cutting out the lode, or "stoping," begins at the point furthest from the shaft, and progresses toward it. With a wide shaft pillar, or with the shaft in the footwall, and with some such general method which avoids concentration of pressure where it can do harm, there seems no reason to anticipate serious difficulties due to crushing for a further depth at least as great as that already attained.

The difficulties of surveying the mine are not markedly increased by depth, except in the case of vertical shafts. When these are deep, and it becomes necessary to carry down an azimuth from the surface by means of two plumb lines hung in the shaft, there is presented a problem of considerable difficulty. It is almost impossible to free the lines entirely from disturbing influences which displace them from their normal positions. If either lines or plumb bobs are of magnetic material the presence of iron pipes in the shaft may result in seriously disturbing them. Falling water may be in such quantity and so directed as also to affect the position of the lines.

However, the air currents, which cannot be wholly eliminated, whatever the precautions taken, are the most serious cause of disturbance. The temperature at the bottom of the shaft is higher than that at the top, and in consequence convection currents are formed. The heat supplied from the surrounding rock keeps them up. Indeed, with moderately steady temperature at the surface, and with the shaft idle, a remarkably stable condition of these air currents may come about. Elsewhere observations have been published by the writer,* showing that their effect on a plumb line may remain sensibly constant for hours at a time while deflecting the line from its vertical position. The stability of the currents is made possible by the large cross section of the vertical shafts, 10 feet by 22 feet to 10 feet by 30 feet outside of timbers, thus giving a large air body, and the constancy of the rock temperatures, and the supply of heat through the shaft walls. When we take account of the fact that a force equivalent to a horizontal pressure of 10 grains on a 60-pound plumb-bob suspended by a line 4,000 feet long will displace the bob one-tenth of a foot from its normal position, it is easy to see how apparently slight causes may produce appreciable error in azimuth.

General attention was first attracted to this problem by the very noticeable divergence of two long plumb lines hung in shaft number five of the Tamarack mine. Of course, divergence alone would not affect azimuth, but the question confronting the surveyor is whether the divergence may not be due to some cause which may also displace one or both of the lines in a direction perpendicular to their plane. In the case mentioned it required a great deal of investigation and experiment to fasten the responsibility on the currents of air.

It is remarkable how many persons are ready to accept as an explanation of such divergence the statement that there is an excess of gravitation on each bob horizontally toward the end wall nearest to which it hangs. All are familiar with the picture in the text-books of the plumb line hanging near the face of a precipice being deflected from the vertical by the attraction of the mountain mass. The idea so strikingly conveyed by this picture while qualitatively correct seems in most minds to be quantitatively wrong. There is an excess of attraction on the bobs as stated, but its amount is far too insignificant to account for any observed divergence. At Tamarack number five it could account for no more than one one-thousandth of a foot. The convergence of vertical lines in that instance is over three times this amount.

The fact remains that the surveyor who must thus transfer an azimuth from the surface down a very deep shaft has a problem, the proper handling of which must involve a careful study of the local conditions, particularly in regard to air circulation.

Increased depth tends to lessen the output of a given shaft, and in the effort to prevent this, and also to reduce hoisting charges, loads have grown larger, likewise the speed at which they are hoisted. Loads of nearly seven tons are being raised on some of the inclines at speeds up to 40 miles per hour.

A considerable item in the hoisting charges is the cost of maintenance of the skip road, the expense per ton for this purpose increasing with the length of the shaft. The usual skip road is carried on heavy timbers which are placed transversely along the foot, and support large stringers to which the rails are spiked. The expense of maintenance of this road for great depths is such that some of the mines are substituting for it a road consisting of a rail attached to a concrete stringer which is borne directly on the rock of the foot-wall.

The stringer proper is about 13½ inches wide by 14 inches high. Beneath it and supporting it is a mass of concrete 16 inches to 18 inches wide extending to the rock. The depth of this supporting mass varies considerably, depending on the irregularities of the rock face to which it is attached. It ranges all the way from 4 inches to 2½ feet, and there is no reason why these limits might not occasionally be exceeded. The stringer and supporting mass are structurally one piece, being molded together. The stringer portion is reinforced by means of a 1⅛-inch steel cable passing longitudinally through its interior. The rail is attached by bolts which are spaced three feet apart, and hold it by means of clips which grasp the rail flange. The bolts pass through the stringer into a rectangular opening about three by four inches in section, which passes quite through the concrete, and affords access to the lower end of the bolt.

* Presented before Section D of the American Association for the Advancement of Science.

* See Engineering and Mining Journal, April 26, 1902, also Electrical World, April 26, 1902.

In building the road a form of plank is constructed having the cross section of the stringer, and a length of 15 feet. To its lower side are nailed the cores for the bolt openings just mentioned. The top is left open. From one to three of these forms are supported in place underground by suitable means, and to the sides are nailed boards extending downward to the rock. These make the form for the supporting part underneath the stringer proper. When all is firmly secured the rock face is thoroughly washed, and the concrete is filled in, beginning at the lower end. The mixture used is one part Portland cement, three of sand and five of crushed rock, and it is tightly rammed in place. As the filling proceeds the top of the form, or the cover, is completed by nailing on short pieces of plank. In the roads which have been built at a slope of 70 deg. the structure is anchored to the foot-wall by heavy bolts spaced 8 feet apart. When the concrete has hardened sufficiently the form is removed and the rail is bolted in place. The road is then complete.

The first of these roads has been operating some three years, and has proved so satisfactory that the others have followed. Expectation regarding cost of maintenance has been fully realized, and, in addition, it has been found that the original cost of the road is less than that of wooden construction. Its disadvantages seem to be confined to the fact that, due to the unyielding nature of the support, the effect of a blow must be absorbed between wheels and rail, resulting in a perceptibly greater deterioration of both. However, this is far more than compensated by the decreased cost in other directions and the fireproof character of the road.

In the effort to counteract the increased costs due to great depth the economical generation, distribution, and use of power have naturally received large attention. The long period of operation necessary makes it worth while to expend large amounts of money in installing machinery of large capacity and high economy. The extreme in the direction of high-duty engines is represented at present in the Nordberg quadruple expansion, two-stage air compressor operating at the Champion mine. The engine is equipped with Nordberg's regenerative feed water heating system. It holds the world's record for minimum consumption of heat per foot-pound of work delivered, having shown a duty of 195,000,000 foot-pounds, being about 9 per cent in advance of its nearest competitor.*

But one mine is so situated as to be able to make use of water power. The Victoria, located near the Ontonagon River, has a considerable water power available which has been utilized in a novel manner. Distance from source to points of application is not great and the power for both mine and mill is distributed by compressed air. Moreover, the falling water operates directly on the air without the intervention of water-wheel or other machine.

Roughly speaking, this "hydraulic air compressor" consists of a large underground chamber cut from the solid rock and having a length of 281.5 feet, a width of 18 feet and a depth of 26 feet. In normal operation the lower portion of the chamber is filled with water to a level of 14.5 feet from its roof. The remainder, having a capacity of over 80,000 cubic feet, is filled with air at 114 pounds gage. The water outlet is through a tunnel 18 feet wide and 10 feet high, the bottom of the tunnel being a continuation of the horizontal floor of the chamber. This tunnel opens into an inclined shaft about 18 by 20 feet in cross-section, the discharge level of which is 271 feet above the water level in the chamber. The outlet for air is a 24-inch pipe leaving the chamber through the roof directly above the tunnel outlet.

The inlet for both water and air is through three vertical shafts, each 5 feet in interior diameter, opening through the roof of the chamber at the end opposite to the outlets. Each shaft is tightly lined with concrete, and is continued down into the chamber by means of a somewhat flaring steel casing to a distance of about 15 inches below the water level. Just beneath, and reaching somewhat into the opening of the casing, is a conical boss of concrete. From water level in chamber through the air- and water-tight shaft to the water level at the intake above is 343 feet. This is 72 feet greater than the distance between the water levels at the outlet end, and this difference expresses the available head of water.

At the intake water is admitted through an annular funnel over a hollow ring from the flat inner periphery of which project 1,800 three-eighth-inch tubes into the annular opening of the funnel. The water must flow over the mouths of these tubes, and in doing so it produces the aspirating effect which entrains the air in small bubbles. The air comes mainly through the tubes from the hollow ring which has suitable intake pipes extending above the water level. The mixed water and air fall through the vertical shaft, and are discharged radially from the annular outlet formed by the concrete boss and steel casing below. The current through the chamber is slow, and the air disengages itself, collecting in the top of the chamber, and displacing the water. By its pressure on the water surface in the chamber it maintains the 271 feet of difference in level between that surface and the one at the discharge of the outlet shaft.

While running at less than full capacity the water level in the chamber is prevented from being depressed further than 14.5 feet from the roof by means of a blowoff pipe, 12 inches in diameter, which opens somewhat below the normal water level. When the water has been pushed down sufficiently air enters this pipe, and its escape relieves the excess of pressure. When the blowoff is in operation the appearance at its mouth greatly resembles the eruption of a powerful geyser. The stream of spray, due to the entrance of water with the air from the chamber, is thrown sometimes to a height of 400 feet.

The capacity when all intake shafts are operating is about 5,000 horse-power. So far but one intake is used. This under test at near its maximum capacity showed an efficiency of better than 82 per cent while delivering 11,930 cubic feet of air per minute at 128 pounds absolute pressure.

All machinery at the stamp mill and at the mine, whether on the surface or underground, is operated by compressed air. Besides utilizing cheap power the compressor has obvious advantages over the usual machine in the absence of parts to get out of order and in low cost of attendance.*

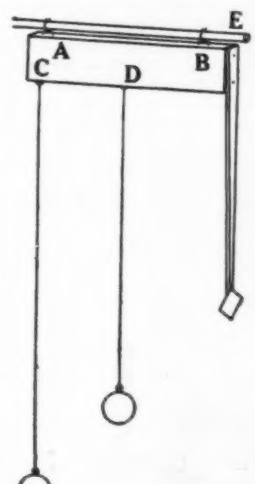
A MECHANICAL MODEL FOR THE LECTURE DEMONSTRATION OF "BEATS."†

By WILL C. BAKER.

THE simple device herein described has annually proved its effectiveness in elementary classes since 1899 in school courses.

A very light pointer—say 50 centimeters long—is fastened to one end of a bit of lath—say 15 centimeters long and 3 centimeters deep—as shown in the sketch. Light staples, made by cutting the heads off stout bent pins, are driven into the edges of the lath at the points lettered *A*, *B*, *C*, and *D*. This system is attached to a fixed horizontal rod, *E*, by strings through the staples at *A* and *B*, leaving it just free to swing with *A* and *B* as hinges. From *C* and *D* are hung two equal masses of about 250 grammes each, by strings 100 centimeters and 75 centimeters long as shown in the sketch. A disk of white bristol board at the pointer end completes the apparatus.

If now the two pendulums be displaced together



through an arc of, say, 15 deg., and then released, the motion of the pointer being controlled by two approximately harmonic forces of different period, will go through a series of beats. The amplitude of the pointer's motion being a maximum when the pendulums are in phase, and diminishing to zero as they approach opposition. The action proceeds so slowly that its progress may be described to a class as it takes place. The rapidity of the beating may be altered by changing the pendulum lengths, and for this purpose a few large pins thrust through the pendulum cord and bent into hooks are very convenient, the pendulum bob being simply lifted from hook to hook as one wishes to change its period.

There is, of course, no obvious relation between the maximum amplitude of the pointer's motion and that of the pendulum, but any attachment to secure this would complicate the apparatus and thus detract from its effectiveness.

INDUSTRIAL ACTIVITY IN 1906 AS EXEMPLIFIED BY FOREIGN TRADE.

AMERICAN manufacturers made their best record in 1906, so far, at least, as their record can be measured through imports of manufacturers' materials or exports of manufactures. In practically all of the great articles imported for manufacturing purposes the records of 1906 show a larger total imported than in any preceding year, while the aggregate value of manufacturers' materials imported, whether in the crude state or in a partially manufactured form for further use in manufacturing, was also greater than in any preceding year. Likewise in exports of manufactures the figures of the year are larger than in any preceding year, fiscal or calendar.

So apparent is this greater importation of manufacturers' materials and greater exportation of manufactures that it is unnecessary to await the December figures to justify the assertion that the record of 1906 will be higher than that of any other year. In practically all of the great articles the figures of the eleven months ending with November, 1906, exceed those of the corresponding months of any earlier year. Running through the list of great articles imported for manufacturing and taking them in alphabetical order, the records of the Bureau of Statistics of the Department of Commerce and Labor show the imports of cement, chemicals, copper, fibers, hides and skins, lumber, rubber, silk, tin, tobacco, and wool; and in all of these, with the exception of fibers and wool, the importations of the eleven months ending with November, 1906, are greater in quantity than those of the corresponding months of any earlier year. Of cement, the imports in eleven months of 1906 were 773 million pounds, against 307 millions in the same months of 1905. Of chemicals, the total value of the importations was 70 million dollars, against 63½ millions in the corresponding months of the preceding year. Of copper, in pigs, bars, etc., the imports were 161 million pounds, against 147 millions in eleven months of 1905. Of hides and skins, the eleven months' importations were 373 million pounds, against 350 millions in the corresponding period of the preceding year. Of lumber, the value imported in eleven months of 1906 was 29 million dollars, against 22½ millions in the corresponding months of 1905. Of india rubber, the number of pounds imported in the eleven months of 1906 was 60 millions, and in the corresponding months of 1905 but 58 millions. Of raw silk, the imports of the eleven months were nearly 15 million pounds, against a little over 14 millions in the corresponding months of 1905. Of tin, the imports of the eleven months of 1906 were 90 million pounds, and in the corresponding months of 1905 were 83 millions. Of leaf tobacco, the imports of the eleven months of 1906 were practically 39 million pounds, against a trifle more than 31 millions in the same period of 1905. The two important articles of manufacturers' materials in which a reduction is shown are fibers, of which eleven months' importations fell from 280 thousand tons in 1905 to 263 thousand in 1906, and wool, of which the imports fell from 234 million pounds in the eleven months of 1905 to 183 millions in the corresponding period of 1906. This falling off in the imports of fibers and wool is the more striking in view of the fact that the importations of manufactures of fibers and wool show an increase in 1906 compared with 1905.

Not only do the quantities of manufacturers' materials show an increase, but the total value of the great groups also shows an increase. The value of manufacturers' raw materials imported in the eleven months of 1906 was 402 million dollars, against 370 millions in the corresponding months of 1905; and the value of manufactures for further use in manufacturing 223 million dollars, against 180 millions in the same months of the preceding year.

The export figures of the year also indicate great activity on the part of the manufacturers, since in the large proportion of cases they show an increase in quantity as well as value of manufactures exported. The total value of manufactures exported in the eleven months of 1906 was, of manufactures for further use in manufacturing, 220 million dollars against 194 millions in the corresponding months of the preceding year, and of manufactures ready for consumption 438 millions against 391 millions in the corresponding period of 1905, thus indicating that the total value of manufactures of all kinds exported during the year will exceed 700 million dollars against less than 650 millions in the preceding year. Iron and steel manufactures exported in the eleven months of 1906, for which statistics are now available, show an increase of 28 million dollars over those for the corresponding months of the preceding year; lumber, an increase of 9 millions; refined mineral oil, an increase of 5 millions; cars and carriages, an increase of nearly 5 millions; pig copper, an increase of 4 millions; instruments and apparatus for scientific purposes, an increase of nearly 4 millions; agricultural implements, an increase of about 2 millions, and naval stores also an increase of about 2 millions.

THE MINERAL PRODUCTION OF THE UNITED STATES IN 1905.

A MOST interesting chapter in the volume entitled "Mineral Resources of the United States, 1905," published by the United States Geological Survey, is that which contains a summary of the mineral production of the United States during that year.

In 1905, for the seventh time, the total value of our mineral production exceeded the enormous sum of $1,000,000,000. The exact figures for 1905 are $1,623,877,127, as compared with $1,360,883,554 in 1904.

As heretofore, iron and coal are the most important of our mineral products. The value of the iron in 1905 was $382,450,000; the value of the coal, $476,756,963. The fuels increased from $584,043,236 in 1904 to $602,477,217 in 1905, a gain of $18,433,981, or 3.16 per cent. Anthracite coal showed an increase in value of $2,904,980 from $138,974,020 in 1904 to $141,879,000 in 1905. The increase in value of the bituminous coal output over 1904 was $29,480,962, a combined increase in value of coal of $32,385,942 in 1905, or 7.3 per cent.

The gain of $262,993,573 in the total value of our mineral production is due to gains in both metallic and non-metallic products, the metallic products showing an increase from $501,099,950 in 1904 to $702,453,108 in 1905, a gain of $201,353,158, and the non-metallic products showing an increase from $859,383,604 in 1904 to $921,024,019 in 1905, a gain of $61,640,415. To these products should be added estimated unspecified products, including molybdenum, bismuth, tungsten, and

* See description and report of test in paper on "A High Duty Air Compressor," by Prof. O. P. Hood, Transactions American Society of Mechanical Engineers, 1906.

* See description by A. L. Carnahan in the Mining World of August 25, 1906, and by C. H. Taylor in Mining and Scientific Press, August 18, 1906.

† School Science and Mathematics.

other mineral products, valued at $400,000, making the total mineral production for 1905 of $1,623,877,127.

Besides the usual table and summary of quantities and values of the country's mineral output by products, the volume contains this year, for the first time, a summary, in tabulated form, of the value of the mineral products by States. These tables were compiled by Mr. William Taylor Thom.

PRACTICAL TESTS OF THE GYROSTAT FOR SHIPS.

By OTTO SCHLICK.

MY gyrostat, or device to diminish the rolling of ships, which was first described about two years ago,

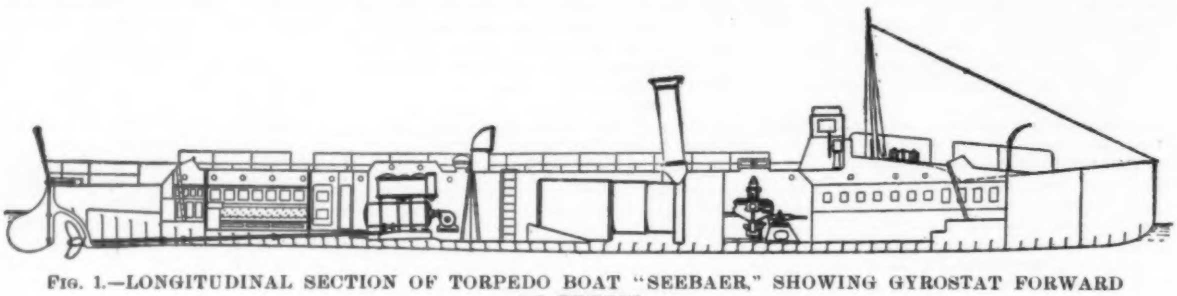


FIG. 1.—LONGITUDINAL SECTION OF TORPEDO BOAT "SEEBAER," SHOWING GYROSTAT FORWARD OF FUNNEL.

was suggested by certain curious phenomena which I had observed in paddle-wheel steamers. One of these is the violent list caused by putting the helm about, which is much greater than can be explained by the centrifugal force due to the turning. In general, paddle steamers roll less than screw steamers and their period of oscillation is longer when the wheels are revolving than when they are at rest. In a seaway a paddle steamer follows a sinuous course which is generally attributed to the alternate raising and lowering of the wheels in rolling. On this theory the depression of the starboard wheel should deflect the bow to port but, as a matter of fact, the bow turns to starboard.

I came to the conclusion, long ago, that these phenomena are caused by the gyroscopic action of the revolving paddle wheels. When the axis of a rotating wheel is turned by external forces about an axis perpendicular to itself there is produced a couple which tends to cause rotation about a third axis, perpendicular to both of the axes above specified. For example, when the shaft of a paddle steamer is turned in a horizontal plane, by moving the helm and changing the course, a couple comes into play which acts to turn the shaft about a horizontal axis running fore and aft and thus to careen the vessel toward the outside of its curved path.

Conversely, when the shaft is turned about a horizontal axis by the rolling of the ship a couple is produced which acts to twist the vessel around a vertical axis and cause it to deviate from the straight course. But this deviation in turn produces a couple which tends to turn the vessel about its longitudinal axis in a direction opposite to the rolling, which is therefore diminished.

My gyrostat is a heavy wheel revolving rapidly about a vertical shaft mounted in a frame supported on trunnions which allow it to turn about a horizontal transverse axis so that the shaft of the wheel swings in the vessel's plane of symmetry. As the common center of gravity of the wheel, shaft and frame is lower than the trunnions the shaft hangs vertical while the vessel is at rest but it swings fore and aft like a pendulum when the vessel rolls.

The arrangement above described, however, would only lengthen the period of rolling, because part of the energy derived from the waves would be consumed in raising the center of gravity of the apparatus as the shaft is deflected from the vertical position. But when the ship had completed its roll to one side and begun to right itself the potential energy of the raised center of gravity would be expended in increasing the rolling motion from which it had been derived so that the amplitude of rolling would not be affected by the revolving wheel.

The addition of a hydraulic brake makes it possible to check the oscillations of the apparatus and indirectly, through reaction, those of the ship. In other words the energy taken from the rolling motion during one phase is not restored to it during another but is converted into heat by the brake so that the energy of rolling is diminished.

Experiments made with small models were surprisingly successful, yet I would not venture to test the invention on a veritable ship until Prof. Foeppl had reduced the mathematical theory to practical form and proved that an effective gyrostat need not be of impracticable size.

In view of the great expense of the experiment and of the increase in practical difficulties with the size of the vessel, the apparatus was installed on the little "Seebaer," formerly a torpedo boat of the German navy. Her approximate dimensions, etc., are as follows:

Length of water line	35	meters or 115 feet.
Greatest breadth	3.6	meters or 12 feet.
Draft	1	meter or 3.3 feet.
Displacement (D)	57	metric or 63 short tons.
Metacentric height (h)	0.5	meter or 1.6 feet.
Period of rolling (T)	4.14	seconds.

The comparatively high metacenter increased the

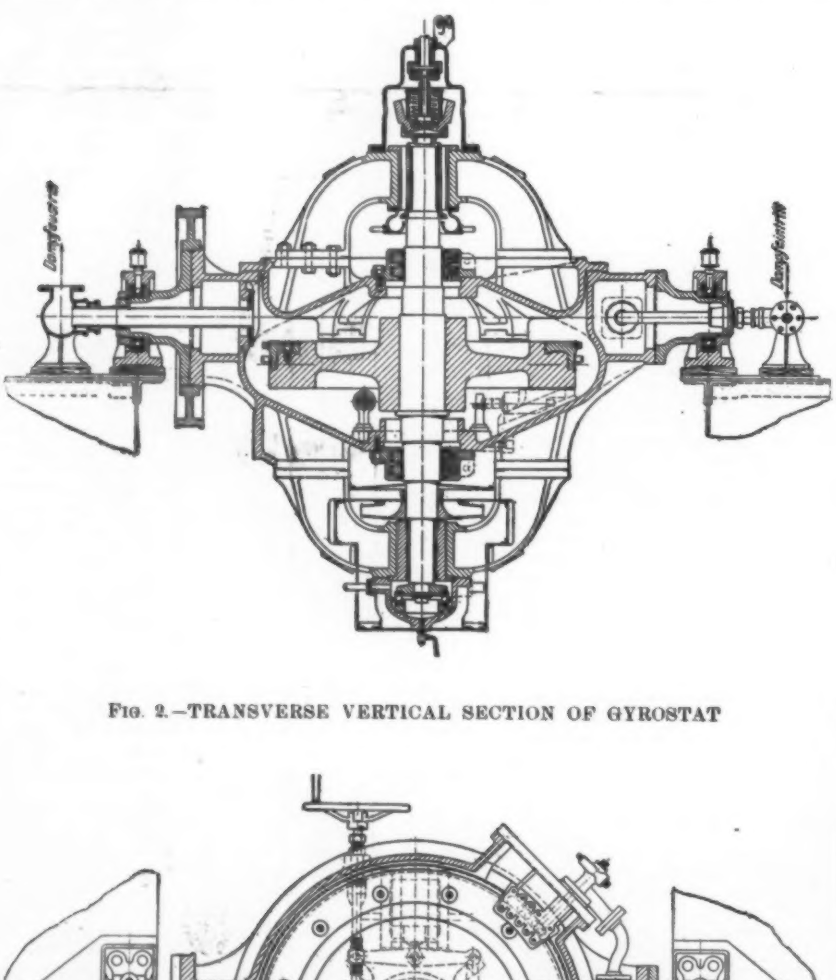


FIG. 2.—TRANSVERSE VERTICAL SECTION OF GYROSTAT

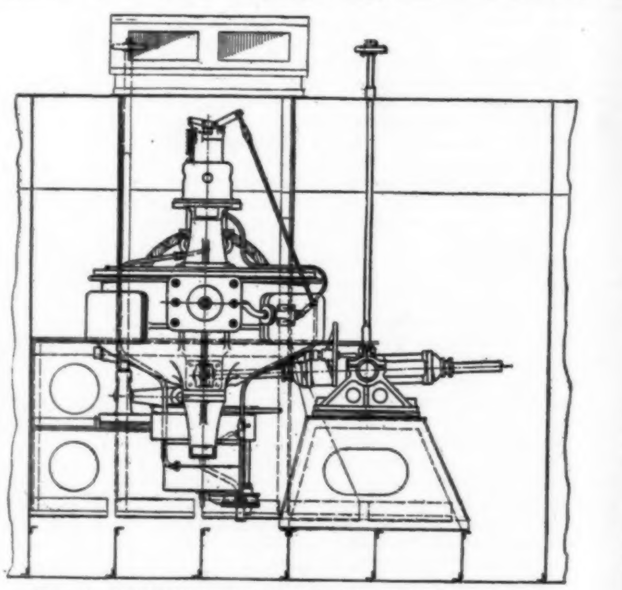


FIG. 4.—SIDE VIEW OF COMPLETE APPARATUS.

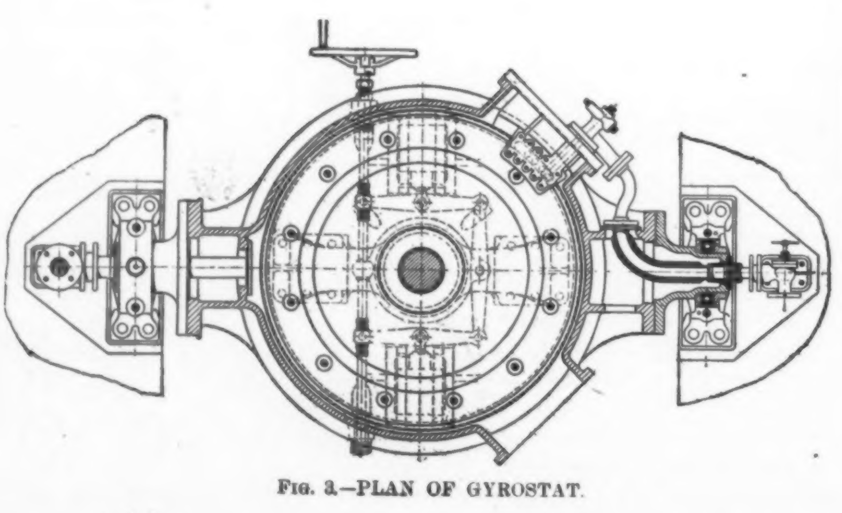


FIG. 3.—PLAN OF GYROSTAT.

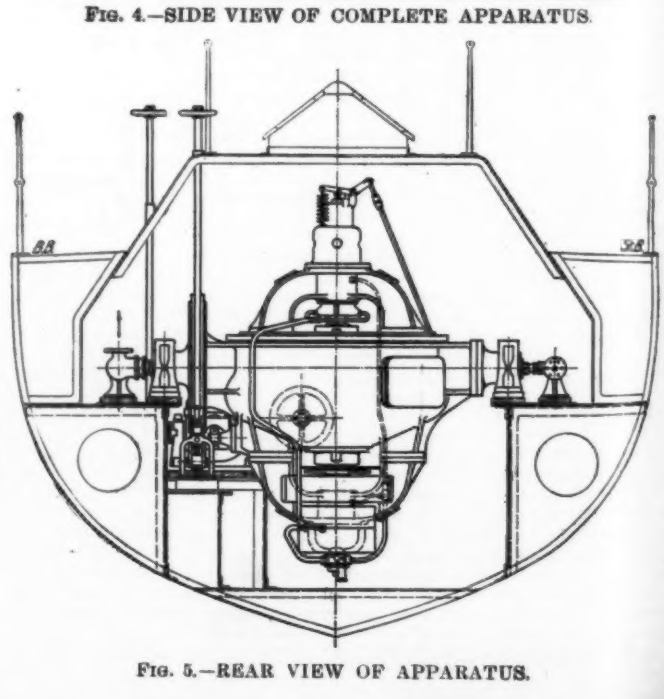


FIG. 5.—REAR VIEW OF APPARATUS.

size of the gyrostat needed to check rolling and hence the severity of the test and the value of the results.

In order to avoid unknown practical difficulties the gyrostat was designed to run at comparatively low speed and made correspondingly large, according to the following table:

Outer diameter of wheel..	1 meter or 3.3 feet.
Weight of wheel, without shaft	500 kilos. or 1,100 pounds.
Velocity of rim..........	84 meters or 275 ft. per sec.
Revolutions per minute..	1,600.

The wheel was a solid block of forged steel. It would have been most convenient, both for installation and for operation, if the wheel had been driven by an electric motor, but as the boat had no electric plant and none could be added without great expense and difficulty I decided to convert the wheel itself into a steam turbine by attaching to its rim rings of reaction surfaces and inclosing it in a shell of cast iron to which were attached the trunnions which permitted it to swing in the median plane of the ship. These trunnions, which rested on ball bearings, are hollow and serve respectively as an inlet and an outlet for steam, like the trunnions of an oscillating reciprocating engine. The lower end of the shaft also rests on ball bearings, which as well as the bearing or guide at the upper end are kept constantly supplied with oil by a chain pump, and cooled by a blast of air from a centrifugal blower. At the upper end is a centrifugal governor which cuts off the steam when the speed exceeds 1,600 revolutions per minute. There is also a device which strikes a gong after each 10 revolutions and thus gi es warning of any irregularity in speed. Finally, there are brakes by which the wheel can be stopped quickly in emergencies.

The brakes which control the oscillations of the apparatus are on the port side. They include a band brake connected with a wheel on deck by which the oscillation can be entirely stopped, and a hydraulic cylinder brake. The piston rod of the latter is connected to a tongue on the side of the gyrostat case and its resistance is regulated by a valve which can be operated either from the gyrostat room or the deck.

In the first experiments the vessel was towed. The performance of the gyrostat was satisfactory in every respect. Not the slightest vibration or jar was felt and the lubricating and braking devices proved their excellence. Occasionally the speed was increased to 3,000 revolutions per minute. No ill effects followed were at rest. When the ship rolled, the wheel remained at rest so that the pointer marked the amplitude of the oscillation. The results of the experiments are shown graphically in Fig. 7. Curves 1 and 2 are from experiments with the gyroscope at rest, the initial lists produced by the crane being 10 deg. and 13 deg. 40 min., and the single oscillations performed before the amplitude fell to ½ deg. being 20 and 25. The other curves are from experiments with the gyrostat in rotation. In the fifth experiment the amplitude fell from 15 deg. 30 min. to ½ deg. in 4, and in the sixth it fell from 6 deg. to ½ deg. in 1½ oscillations. These results show that the gyrostat has a great damping effect on the oscillations.

The main experiment was the test of the apparatus with the vessel steaming at sea. After several trips which gave no results of value because of the calmness of the sea, the experiments illustrated by Figs. 8, 9, and 10 were made in the delta of the Elbe, in the following manner:

The gyrostat was driven at normal speed, 1,600 revolutions per minute, but at first its shaft was held vertical (or rather, perpendicular to the deck) by the band brake attached to its case. The rotation of the wheel in this fixed position has no effect on the rolling of the ship. The vessel steamed slowly at right angles to the direction of progression of the waves in order to make the rolling as great as possible, and the amplitude of oscillation was measured with the small graduated wheel described above. The diagram of July 17 (Fig. 8) shows a maximum weather roll of 15 deg. and a maximum lee roll of 25 deg.; those of August 21 (Figs. 9 and 10) show maxima of 15 deg. in each direction. This is pretty violent rolling.

After the rolling had been observed and measured for several minutes the band-brake was cast loose. The gyrostat and its case began to swing violently and the rolling of the vessel was at once reduced to an average amplitude of ½ deg. with an occasional roll of 1 deg., as is indicated in the lower part of the diagrams, below the point A. The boat behaved very well, much better, indeed, than when the gyrostat was not acting. The waves appeared to pass under the hull, gently lifting and lowering it without even throwing much spray on the deck. The prediction of nautical experts that the boat would ship heavy seas under the influence of the gyrostat was not fulfilled.

In order to study the effect of lower speeds the revolutions of the gyrostat were reduced to 1,200 per minute. No difference in the effect was observed, but at 1,000 revolutions the damping effect was slightly lessened, and at 800 revolutions the maximum amplitude of rolling attained was 3 deg. With the gyrostat made ineffective by braking deflections of 12 deg. were observed. From this it appears that the gyrostat of the "Seebaer" was much larger than it need have been for a speed of 1,600 revolutions.

The experiments give reason to believe that the gyrostat can be applied with equal success to larger vessels. In practice, however, several changes should be made in construction and operation. The speed of rotation should be greatly increased, which can safely be done if the wheel is properly shaped and made of very strong steel. This would allow the diameter of the wheel to be diminished.

For example, if the speed of the gyrostat of the "Seebaer" had been doubled the same damping effect would have been produced with a diameter of 70 centimeters (27.6 inches). As the wheel actually used was unnecessarily large for a speed of 1,600 revolutions a diameter of 60 centimeters (23.6 inches) making 3,200 revolutions, would have sufficed.

The gyrostat should also be driven by an electric motor, in order to facilitate cooling of the bearings.

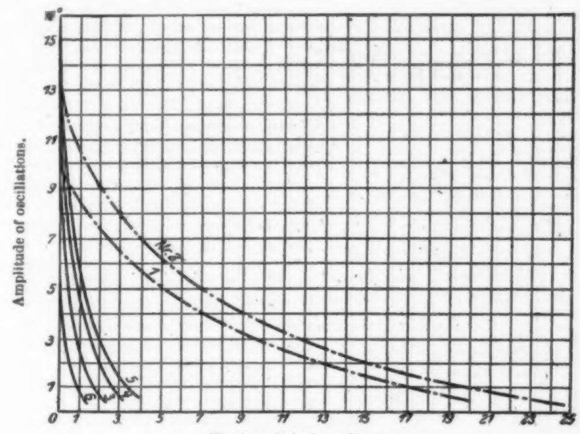


FIG. 7.—CURVES OF DAMPING.

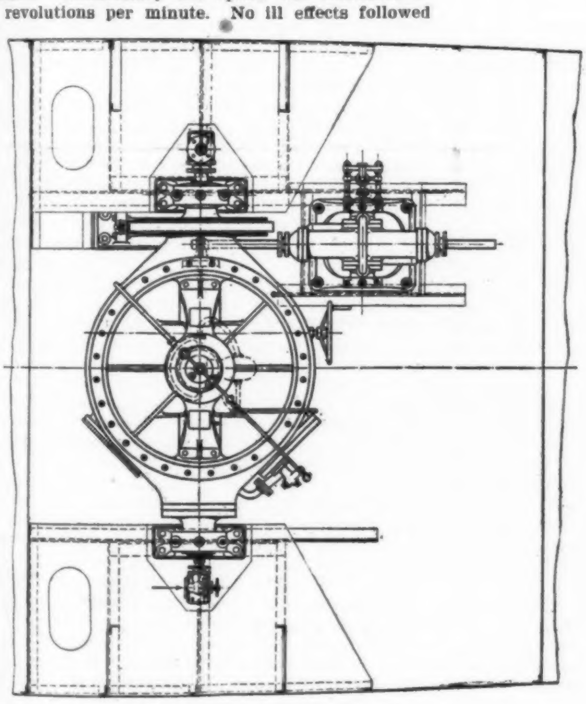


FIG. 6.—APPARATUS SEEN FROM ABOVE.

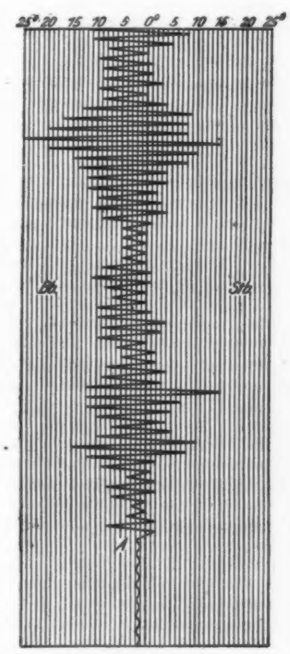


FIG. 8.

EXPERIMENT OF JULY 17, 1906.

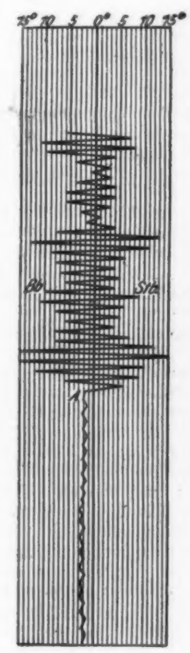


FIG. 9.

EXPERIMENT OF AUGUST 21, 1906.

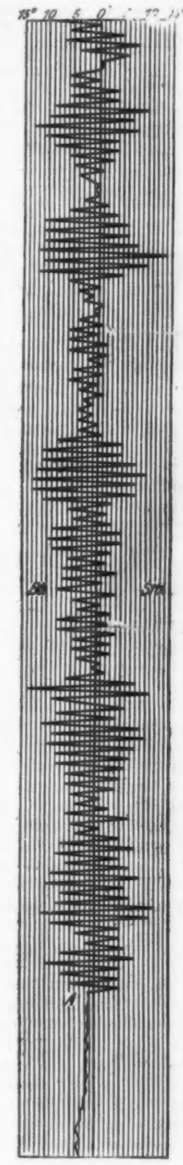


FIG. 10.

EXPERIMENT OF AUGUST 21, 1906.

and I shall not hesitate to employ this high speed for gyrostats as small as this one.

Next, the boat was caused to roll by moving the crew from one side to the other. The time occupied by a double oscillation (from starboard to port and back to starboard) was 4.14 seconds when the gyrostat was at rest and about 6 seconds when it was making 1,600 revolutions per minute. In the latter case the smallness of the oscillations made the observations very difficult.

Then experiments were made to determine the number of oscillations that took place while the amplitude of oscillation decreased from an arbitrary initial value to ½ degree. For this purpose the boat was inclined about 15 degrees by raising one side with a crane and suddenly released. The amplitude was measured with a simple instrument consisting essentially of a heavy wheel, 60 centimeters (2 feet) in diameter, with its axle horizontal and parallel to the axis of the ship, at the level of the center of gravity of the latter, and mounted on ball bearings. The center of gravity of the wheel was a little below the axle and the period of oscillation 20 seconds. The rim of the wheel was graduated in degrees and turned under a fixed pointer, which indicated zero when both the ship and the wheel

There is every reason to believe that the field of usefulness of the gyrostat will not be restricted to small vessels. The Hamburg-American line has already decided to install the apparatus on one of its passenger steamers employed in the excursion service. —Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Zeitschrift des Vereins Deutscher Ingenieure.

In large gas-engine power plants the item of fuel cost is composed, besides the price for the coal, of the expense of handling it between the car and the ash pile, including sufficient fuel storage capacity to guarantee permanence of production during all emergencies, and especially against interruptions in the supply service, such as are occasioned by strikes, railroad accidents, car or locomotive famines, etc. It is obvious that with the reduction of the fuel bill to one-third, the interest on the amount of capital locked up in the coal stored, and in the storage equipment, as well as the cost of operation and upkeep, are correspondingly reduced. With the same investment the gas power plant can tide over periods of fuel shortage, and keep up production when the steam competitors would have to shut down.

THE NEW INCANDESCENT ELECTRIC LAMPS.—I.*

The great competition which the incandescent electric light has had to face since the introduction of the incandescent gas light has given a strong impulse to the efforts which have been made to improve incandescent electric lighting in technical and economical directions. The principal improvements have been in the direction of the application of substances other than carbon for the manufacture of the light-giving body—as, for instance, in the Nernst, osmium, and tantalum lamps—and toward the further development of the existing systems of incandescent lamps using the carbon filament. The latter direction makes for the solution of the question in the application of lamps of high tension, the other in the employment of low voltage lamps. The high voltage lamps, however, have only been made so as to be efficient when high light powers are concerned, and the low voltage lamps have turned out to be uneconomical. The first Edison lamps required 4.5 to 5 watts per candle-power, while for the last twenty years lamps have been produced which use 3.5 watts per candle. Many special lamps, devised for high tension, work even with only 2.5 to 3 watts per candle, and have at the same time a good illuminating power and a relatively long life. The power of the carbon electric lamps seemed to have reached its end, for all attempts to impart greater resistance to the carbon filament by the addition of other substances have turned out of no avail. As an infusible body carbon is an ideal substance for incandescent electric lamps, if it had not the unpleasant property of disintegrating during incandescence in a vacuum, whereby the glass walls are blackened, and on this account a considerable amount of light absorbed. But furthermore also the alteration of the structure of the carbon filament, in conjunction with the disintegration, is connected with a greater consumption of current to produce the same light, so that through these two factors the economy of the lamp is in no small way prejudiced. The disintegration is hastened with rise in temperature, so that incandescent carbon lamps for tensions of 200 to 250 volts lose their illuminating power more quickly, and have, accordingly, a much shorter life in practice than low-voltage lamps, say up to 110 volts. Consequently, much improvement in the carbon filament lamps cannot be expected. Efficient lighting demands in an economical source of light the highest possible temperature of incandescence, and the efficiency depends upon the law that the amount of light which an illuminating body emits increases with the fifth power of its temperature—that is to say, extraordinarily rapidly. An example will make clear the great importance of this law. An electric incandescent lamp whose carbon filament has a temperature of 2,000 deg. absolute, and emits light of 30 normal candle-power, would at double the temperature, 4,000 deg. absolute, emit not twice the amount of light, but 2 × 2 × 2 × 2 × 2 times the amount—that is 32 times the amount, or about 1,000 candle-power. At the same time, the amount of current used decreases with rise of temperature.

On account of the above principle researches have been directed toward the discovery of other bodies which are better adapted than carbon for light-giving bodies in incandescent lamps. Nernst assumed that among the metallic conducting bodies—the so-called conductors of the first class—no substance existed which was adapted for the production of an economical lamp; he turned, therefore, to the conductors of the second class—the so-called electrolytes, which are decomposed by the electric current. It was ascertained that the oxides of magnesium, zirconium, thorium, yttrium and other metals of the rare earth series, which do not conduct the electric current at all at ordinary temperatures, soon lose their electrical resistance with rise of temperature, and become decidedly good conductors. It was found also that by a suitable mixture of the earths—zirconium earth and yttrium earth—the decomposing action of the current could be for the most part prevented, but the property of the conductors of the second class—namely, to conduct the current when heated—proved a great and fundamental disadvantage of the Nernst lamp which has hitherto not been overcome. The heating-up arrangement of this lamp is undoubtedly its most wonderful feature, and has been the object of by far the most attempts at improvement. Efforts have not been wanting to overcome the last-named evil by an ingenious combination of the Nernst lamp and the carbon filament lamp, but their great sensibility to variations in current and the inconvenience of their slow lighting militate largely against their general use.

The same inventor to whom gas-lighting owes its rescue has given a new weapon to the supporters of electric lighting. Toward the end of the ninetieth year of the last century Auer von Welsbach was occupied in the production of a better incandescent material for electric lamps, and he discovered that a very suitable metal was osmium, one of the elements in the platinum group. This metal can only be fused in the electric arc. Since osmium, on account of being exceedingly brittle, cannot be drawn in the form of wire, Auer had to find a special process to convert amorphous osmium metal into wire form. From finely powdered osmium metal a paste was prepared by the addition of some organic binding material, from which, by means of a press, very thin threads were produced. These were dried, and finally heated in vacuo until the organic matter was carbonized, and became a conductor of the electric current. The filaments, which contained osmium and carbon in a very fine state of division, were then heated to the highest white heat for a long time in an atmosphere of reducing gases, such as hydrogen saturated with steam. In this operation the carbon was eliminated, and the fine particles of osmium remained behind united in a solid wire.

The great question in connection with the osmium lamp was the difficulty of obtaining osmium in quantities necessary for the manufacture of the lamp. Until quite recently osmium was only produced in small amounts as a by-product in the manufacture of platinum. To produce osmium lamps on a large scale, however, demands much larger quantities. After Auer von Welsbach had bought up all supplies of osmium, he came before the public with his invention. Immediately the price of osmium, which had formerly no practical application whatever, went up to the figure of £250 per kilo. But the Auergesellschaft announces that it is provided with enough osmium for several million lamps, and for current requirements, and no doubt it hopes to recover the greater part of the material going out by sale, since it allows 9d. per lamp for all those returned. A mining company has also been formed under its auspices, which will attend to the further delivery of osmium in sufficient quantities.

Just as the metals in the solid form conduct the electric current, so they do in the liquid and gaseous conditions. The conduction of the current by mercury vapor is one of the oldest methods of producing electric light; an Englishman, Way, as far back as 1860, pointed out the great production of light which this process afforded. After this early investigation the mercury lamp was long forgotten; twenty years later it was heard of again, through the patents of Rapieff and Rizet on the subject. These, however, as well as the patent of Langhaus—1887—found no wider application than for laboratory purposes. The mercury lamp of Arons—1892—marked a real advance, but this also found no general application as a means of illumination. The first investigator so to improve the mercury lamp as to give it practical value was Peter Cooper Hewitt,* who a few years ago conducted careful inquiries into the electrical properties of quicksilver vapor. Hewitt found as the essential condition for the construction of a useful lamp, that in the interior of the lamp, a definite temperature and gas density must prevail in order to produce an economical and advantageous light. The principal factor which militates against the general introduction of these lamps is the fact that the color of the light is bluish green. The red rays are absolutely missing, so that all colors are altered. The mixture of light of the Hewitt lamp is therefore of a different basis from sunlight. In all light phenomena there exist, besides the light-giving visible rays, also dark rays which are not perceptible to the eyes. These dark rays consist of two kinds, the ultra-red or heat rays of long wave-length, and the ultra-violet photographic, chemical, or actinic rays of short wave-length. While the light and heat rays from the action of the sun and all artificial sources of light have been known and used for a long time, the discovery of the ultra-violet rays is due to more recent investigation with highly perfected apparatus.

In the course of the last ten years physicists and physicians have shown that this emission of energy, the ultra-violet rays, is not only of scientific interest, but is connected with valuable properties for the use of mankind. Hence grows the need to make accessible the apparatus and contrivances with which it is possible to produce this class of rays in addition to the heat and light rays in a convenient and economical manner. For this purpose the Hewitt lamp served as an excellent foundation. Since ordinary glass does not allow the ultra-violet rays to pass through, but absorbs them, it was therefore necessary to choose some other material, and fused rock-crystal was found to satisfy this requirement. Then the firm, W. C. Heraeus, of Hanau, manufactured mercury lamps out of quartz glass, which attracted considerable attention at a scientific congress held in Breslau in 1905. The strong odor of ozone revealed the quantity of ultra-violet rays produced in the vicinity of these lamps by their action upon the oxygen of the air. The spectroscopic test of the wave length of the light emitted showed that the rays possessed wave lengths up to the extent of 220 $\mu\mu$.† The question arises whether the high price of rock-crystal and its tendency to break would stand in the way of the general application, especially for medical purposes, of the quicksilver lamps. In the well-known glass works of Schott and Genossen, in Jena, Dr. Zschimmer had recently produced a peculiar kind of glass which readily transmitted ultra-violet light. Dr. Schott, the well-known colleague of Abbe, could, therefore, taking the new glass as a basis, bring about improvements in the mercury lamp, which answered the requirements of all scientific and practical purposes. Since the spectrum of the new glass composition called the "Uviol"—i. e., ultra violet—of Schott attained the figure of 253 $\mu\mu$, this is quite sufficient, in fact perfect, for medical purposes, because the rays of very short lengths can be neglected on account of their very small power of penetration. The visible part of the spectrum only extends from 579 to 405 $\mu\mu$, and a long range of chemical active rays two-thirds of the length of the spectrum are here excluded. The special mercury lamps of Heraeus and Schott‡ are accordingly extraordinarily advantageous contrivances for transforming electrical energy into useful radial energy of small wave length. Since it contains rays of short wave length, this source of light will probably be of very great use in photography. The special mercury lamps of Schott (Uviol) and Heraeus (quartz) are excellently adapted for exposures and printing by artificial light in northern climates with their short and dark winter days. These lamps will also be of importance for the textile industry in testing the fastness to light of different dyestuffs.

The bleaching action of sunlight is a slow working chemical process, which is to be traced back to the action of the ultra-violet rays. The unfavorable climatic conditions in our regions compel the dye manufacturers to get their tests of the fastness to light of their colors carried out in the sunny South, since all kinds of artificial light—including also the electric arc light—do not produce the same result as the sun. The numerous attempts to carry out these trials with the Uviol lamp have turned out successfully, and the question of the fastness of colors to light will probably be settled in the future in the same number of days as formerly it took months to find out. The rays of the Uviol lamp exercise a striking death-dealing action upon small insects. A house-fly succumbed in one minute when placed about 1½ centimeters from the source of the rays, in circumstances such that the heat could do no harm. Under a lamp which was placed by an open window in a room one summer's night, one could sweep up in the morning thousands of small dead gnats. Similarly, still smaller forms of life, such as bacteria, under the influence of the mercury lamp as with the sun, rapidly die.

The so-called fluorescent lamp, constructed by Dr. Schott, and recently brought by him before the scientific conference at Meran, is merely a variation of the Uviol lamp, in which a larger portion still of the long wave rays are suppressed and removed; it burns, therefore, somewhat dull; while the exterior and the attendance are the same as for the other lamps. In the light of this lamp everything appears pale and unreal. While the lamp itself burns comparatively dull, it produces in its surroundings widespread fluorescence on different substances, for instance, rhodamine, fluorescein, and uranium glass, so that such substances give more illumination than the lamp itself. But vaseline, lanoline, soap, and the human skin also exhibit a peculiar play of color. Since in the latter case changes in the skin imperceptible by daylight become visible, we, therefore, possess in the Uviol lamp not only an inestimable medium for therapeutic and pathological purposes, but also for diagnosis. This fluorescent lamp, which has, of course, a very considerable value for the furthering of physical science, will also be turned toward the treatment, by means of fluorescent solutions, of the so-called sensibility of light, which plays an important part in medicine. These operations are also to be explained by the chemical action of light, through the ultra-violet rays.

Hertz had discovered that ultra-violet light had the power of setting free negative electrons of a radiating body. Consequently the special mercury lamp will also produce ionization; an electroscope brought into its neighborhood shows this fact very clearly, which, like the fluorescence above described, reminds one very much of the properties of radium. In all work with the ultra-violet rays it is necessary to protect the eyes with spectacles in order to prevent serious inflammation of the eyes. Fifty years ago the French savants Regnault and Foucault advanced the view that the violet and ultra-violet rays might be injurious to the eyes, because they produced fluorescence in the humor of the eye, which fatigued the optic nerve, and altered the transparent cells of the eye. Since the quicksilver light is very reactive chemically, so the "sight-purple" of the eye, as König names the agent of vision, will be more used up by this illumination than by the methods of illumination formerly in vogue. For hygienic reasons those kinds of illumination which give a yellowish or reddish light are, therefore, to be preferred. Since the peculiar unpleasant color of the light of the Hewitt lamp is the greatest drawback for its general use, great pains are being taken to compensate the color of the light. The simplest way of overcoming this difficulty should be by means of the so-called orthochrome lamp* by combination of ordinary incandescent electric lamps, or by inclosing the mercury waves in red waves by means of the fluorescence of rhodamine. The most valuable property of the Hewitt lamp appears to me to lie in its property, discovered by Hewitt, of transforming a transmitted alternating current into a direct current.

Many attempts have already been made to replace mercury by other metals, but always with negative results; the powdering and deterioration of the negative electrode is just as bad with other metals. Also, by the use of other gases for preserving the mercury electrode no results worth calling have yet been produced. Werner von Bolton turned back to Auer's idea, and so came to the tantalum lamp. Tantalum is a metal whose melting point—2,250 degrees to 2,300 degrees C.—lies far higher than that of platinum, which has already been used by Edison for incandescent lamps, but without any success. Like osmium, it has the property as metal that its electrical resistance increases on heating. At ordinary temperatures it amounts to 0.165 Ω, for 1 millimeter length and 1 square millimeter diameter; at the ignition temperature of the lamp, on the other hand, 0.850 Ω. The tensile properties of tantalum in the cold state are very good—93 kilos. / square millimeter, the corresponding figure for good steel, is, according to Kohlrausch, 70 to 80 kilos. / square millimeter—so that it can be rather easily worked; on heating, however, it becomes, like osmium, soft, and after 200 or 300 hours burning, very brittle. The diameter of the filament is 0.05 millimeter to 0.035 millimeter; at 0.05 millimeter a 25-candle-power lamp for 110 volts requires a filament length

* Engineer.

* See The Engineer, January 16, 1903.

† 1 $\mu\mu$ = 0.000,001 mm.

‡ See the Chemiker Zeitung, 1906, p. 4, on the Uviol lamp; also SCIENTIFIC AMERICAN SUPPLEMENT No. 1586.

* See The Engineer, January 20, 1905.

of 650 millimeters, which weighs 0.022 gramme, so that 1 kilo. of tantalum metal will make 45,000 lamps. To bring such a length into curved form, as in carbon filament incandescent lamps, is practically impossible. The osmium lamp, which was only used with comparatively low voltage, had the same defect if the curved form were preserved. The beginning of the tantalum lamp consists, therefore, in the application of a frame on which the necessary length of wire is wound. The patents of Siemens & Halske and Scholvien—German patent 159,096—relating to this may include all possibilities in the application of long metal wires for incandescent electric lamps. A process has also been protected by Siemens & Halske to manufacture fused tantalum from the amorphous variety, as well as the application of drawn tantalum wire, and wire from other difficultly-fusible metals, such as zirconium, thorium, yttrium, and erbium—German patents 165,057, applied for October 14, 1904, granted November 24, 1905; 169,565 of May 3, 1903, granted April 5, 1906—for incandescent electric lamps. In order to prevent any possibility of the formation of carbides which would bring about the rapid destruction of the lamp, the pulverized amorphous metal is pressed without the aid of any organic binding material into disks or pads, and then fused in the electric arc in the absence of air or in the presence of some inert gas.

A piece of tantalum heated to redness is transformed under the steam hammer into a thin metal plate, which by heating to incandescence and hammering acquires a hardness like hardened steel, although still flexible.

Siemens & Halske intend to manufacture tools and other articles out of tantalum alloys, and the German patent No. 167,217 granted to this firm means, perhaps, the end of an extensive, and since the twentieth year of the last century, vigorous industry. The tantalum pen is said to have a great resistance against chemicals, to be much harder and more elastic than the steel pen, and on account of this hardness and elasticity, to be indestructible. It exceeds in elasticity the well-known gold nib of the fountain pen, and so these two kinds of writing pens will soon be supplanted, if they succeed in manufacturing tantalum metal at an acceptable price.

In the last annual report of Siemens & Halske it is stated that a large laboratory for the chemical and metallurgical part of tantalum production will be set to work in the early future. Since the obtaining of tantalum mineral now gives no great difficulty, and almost any quantity can be bought cheaply daily, it is to be hoped that the most modern branch of industrial chemistry will soon occupy itself in the valuable production of tantalum metal.

(To be continued.)

CHEMISTRY AND AGRICULTURE.

It has well been said that an experiment is a question put to Nature, and that Nature always answers every question truthfully, but the question that Nature answers and that the experimenter asks is not always the question that he thinks he asks.

In order to determine with certainty the definite cause of a given effect, we must first eliminate other causes or influences which might contribute to that effect. This applies not only to simple qualitative analysis, but also to the application of chemistry to the development of agricultural science and the control of agricultural practice. Chemistry already controls in large measure many industries. Iron and aluminium, zinc and copper, silver and gold, and other metals are extracted and refined by methods largely developed and controlled by chemistry, the preparation and mixing of materials being based upon chemical analysis. Soap, starch, sugar, paper, gunpowder, and fertilizers are only examples of products now manufactured under chemical control.

Progress in agriculture demands that to the greatest possible extent practice shall be controlled by science, not by chemistry alone but by every science that deals with principles fundamental to agriculture. Every science that can contribute to agricultural development is a necessary, and should be a loyal, servant to agriculture, the industry upon whose success rests all industries and all civilizations.

It is only the ignorant who say agriculture is simple. To analyze an unknown substance, to operate a mine or a factory, to manage a bank or a bank failure, to drive a railway locomotive, to erect a cathedral, or to bridge Niagara—these are simple compared with raising on an acre of land the largest crop of corn possible with maximum profit.

Who has sufficient knowledge to select the best seed? What should have been its breeding? What kind of land shall be chosen? How and when shall it be fertilized? What crop rotation should have preceded? Who knows how best to prepare the seedbed? At what time shall the corn be planted? What should be the temperature and the moisture content of the soil? What distance between and how many kernels in the hills? No man to-day can answer any one of these questions with certainty or with satisfaction, and the seed is not yet germinated in the soil, where the bacteria, the fungi, and the insect enemies await the young plant.

The factors and influences are many, but every effect has its cause. Many can contribute to the science of agriculture by gathering facts, but few can interpret the meaning of the facts gathered.

While it is easy to accumulate exact chemical facts, it is easier still to promulgate erroneous agricultural conclusions; and not only the science but the practice of agriculture has suffered, and is suffering to-day, from an insufficient accumulation of facts and data and from an over-production of theories and conclusions.

About three hundred years ago Van Helmont, a Flemish alchemist, planted a five-pound willow tree in 200 pounds of dry soil. He watered it with rain water for five years, and then found that the tree had gained 164 pounds and that the soil had lost only two ounces in weight. Therefore, he concluded, water is the source of plant food. While it seemed to him that his evidence was strong and positive, we all know that his conclusion was wrong, and that the air, the water, and the soil are all essential sources of plant food.

In 1822 William Corbett, in his compilation of the writings of Jethro Tull, made the following statements:

"Mr. Tull's main principle is this, that tillage will supply the place of manure; and his own experience shows that a good crop of wheat, for any number of years, may be grown every year upon the same land without any manure from first to last.

"Mr. Tull continued his wheat crops to the harvesting of the twelfth upon the same land without manure; and when he concluded his work, . . . he had the thirteenth crop coming on, likely to be very good."

It is now known that the conclusion drawn by Tull and Corbett was wrong, although a theory recently promulgated by the United States Bureau of Soils, "that practically all soils contain sufficient plant food for good crop yields," and "that this supply will be indefinitely maintained," is in accord with the teaching of Jethro Tull. Indeed Tull's data are perhaps as trustworthy and conclusive as any thus far reported in favor of this theory.—Cyril G. Hopkins in a bulletin issued by the University of Illinois.

THE SLEEPING SICKNESS.

By A. Acloque.

Public attention has recently been strongly directed toward the terrible sleeping sickness, which at first aroused little interest because it was supposed to be a merely sporadic and comparatively mild disease. On the contrary, it is easily transmissible, epidemic in character, and threatens, if not checked, to depopulate equatorial Africa.

Without repeating oft-published details, it is sufficient to recall that the immediate agent of the disease is a blood parasite, *Trypanosoma zambaise*, one of the flagellate protozoa. The sleeping sickness, therefore, belongs to the class of trypanosome diseases, which are caused by protozoa introduced into the body by blood-sucking insects. (Greek *trypanon*, a boring tool, and *soma*, the body.)

The tsetse fly, *Glossina palpalis*, and its congener *G. fusca* are the insect carriers of the sleeping sickness. The tsetse swarms on the mangrove-covered banks of West African streams, and is very annoying in the hot season. Attempts made in Gambia to transmit the sleeping sickness to animals by the intermediation of this insect gave no decisive results. The conjecture that the tsetse is the carrier of the disease was published, independently, by Sambon and Brumpt in 1903, and the proof was furnished by Bruce and his collaborators, who succeeded in inoculating monkeys with the sleeping sickness by exposing them to the repeated attacks of tsetse flies which had sucked the blood of negroes smitten with the disease.

Bruce, Nabarro, and Greig have made maps of the Uganda showing the geographical distribution of the sleeping sickness and of the tsetse. The two maps correspond closely.

Although these facts might appear to fix the cause of the malady, several points are still obscure, and the solution of the problem, eminently desirable for economic as well as humanitarian reasons, has not yet been reached. A French commission, appointed to investigate the subject, started for Brazzaville last October.

All of the powers which have African colonies have been compelled to give attention to the sleeping sickness. Portugal took the initiative in investigation. Afterward England established permanent experiment stations under the direction of Major Ross, and Prof. Koch received a subsidy of 100,000 marks ($25,000) from the German Emperor and was sent to Uganda, where he is now. The King of the Belgians recently set aside a research fund of 200,000 francs ($40,000) and founded an international prize of 300,000 francs ($60,000).

The French commission was organized by the Geographical Society of Paris, which raised a fund of 200,000 francs ($40,000). Technical instructions and the programme of researches were furnished by a committee of specialists selected by the International Scientific Association. The members of the commission are Dr. Martin, of the French colonial troops, already distinguished by his studies of typanosome diseases in Guinea; Dr. Lebœuf, of the colonial troops, and MM. Weiss, Rambaud, and Muny. The commission is placed under the authority of the minister of the colonies and the commissary-general of the French Congo. All physicians in the French Congo have been invited to communicate their personal observations to Dr. Martin, who will thus be enabled to extend his investigation over an immense territory extending from 15 degrees north to 5 degrees south of the equator.

The following are the chief problems which the commission must solve in order to plan an effective campaign against the disease:

In the first place, it will be necessary to ascertain whether the relation between the geographical distribution of the disease and that of the Glossina is maintained throughout. For this purpose it will be necessary to make, for the whole of the vast region, maps similar to Bruce's maps of the Uganda, showing, on one hand, the infested and, particularly, the exempt localities and, on the other hand, the geographical limits of the *Glossina*, the localities infested by the different species, singly and collectively, and the localities in which no species of the insect has yet been found.

It is evident that the entire value of the apparent connection between the tsetse and the sleeping sickness depends on the elimination of swamp fever, ankylosis, filariosis, and other diseases which might be mistaken for the sleeping sickness. For this purpose early diagnosis by microscopic examination of the blood is necessary.

As there is reason to believe that certain vertebrates in the wild state, including fishes possibly, may serve as hosts of the *Trypanosoma* and therefore as sources of the virus carried by the tsetse flies, the commission will study all trypanosome diseases of animals that may be found to exist in the French Congo.

The researches of Laveran and Mesnil have shown that some Cercopitheci (green monkeys) and all macaques, as well as ouistitis, dogs, cats, and hedgehogs, are very sensitive to trypanosome diseases. Chimpanzees, rodents (especially rats and mice), goats, sheep, horses, and asses are less sensitive, and in them the disease is curable. Hogs, baboons, and some of the green monkeys are entirely immune. According to Bruce, the Bovidæ are also immune, but other experimenters claim to have infected cattle with the disease. These experiments must be repeated, verified, and extended with especial reference to the sleeping sickness.

A very important point in the life history of the trypanosome is still uncertain. Is the tsetse fly merely a passive vehicle for the protozoan, or does the latter complete one stage of its development in the body of the fly? This question is not of theoretical and biological interest alone, it is also of great practical importance. If the fly is only a vehicle, it is evident that the danger of its bite decreases in proportion to the length of time that has elapsed since the same fly sucked the blood of an infected animal. If, on the contrary, the tsetse is a necessary alternative host of the trypanosome, time is required for the change which the parasite undergoes in the body of the fly, which will, therefore, not be able to transmit the disease until the expiration of a definite interval of time after its own inoculation.

The biology of the fly must also be studied, and it must be determined whether the disease can be carried by other species of *Glossina*, in addition to *G. palpalis*, the tsetse, or by insects of other genera. Insects open to suspicion include *Stomoxys*, *Haematobia*, gadflies, mosquitoes, and perhaps bedbugs.

The points in the biology of the arch enemy, the tsetse or *Glossina palpalis*, which especially need elucidation are the following:

The habits of the insect and the places in which it lurks before and after it attacks; the seasons of its greatest abundance; the wild animals which it attacks, regularly or occasionally; and, above all, its mode of reproduction.

From the knowledge of these four points a rational method of destruction may be devised. The last point is of especial importance, for if the mode of reproduction were known, it might be possible to find a substance that would destroy the larvæ, and to wage against the tsetse a war similar to that which has been carried on so successfully against the mosquitoes that serve as carriers of malaria and yellow fever.

The commission will also have to study methods of treatment and protection and, in particular, to test thoroughly those remedies that have already been found useful (atoxyl, arsenious acid, and trypanroth) and to elaborate a plan of protective sanitation, consisting chiefly of the destruction of the tsetse and the isolation of patients in hospitals established in districts not infested by this dangerous insect.—Translated for the Scientific American Supplement from Cosmos.

An important pioneer survey for the construction of a railroad has just been completed in the southern part of British North Borneo by the Government Survey Department. Previously the penetration of this country has been rendered impossible, owing to the ferocity of the Dyaks or head hunters, who massacred all the members of a previous expedition for this purpose with the exception of three natives accompanying the party and who succeeded in effecting their escape. The successful accomplishment of this expedition marks the first occasion in which the interior of the country has been traversed by Europeans. The party comprised four European officials escorted by fifty military police and assisted by one hundred native carriers, but the party were not molested at any time during the journey. The object of this mission was to complete the surveys of the country, about which nothing has hitherto been known, for the continuance of the transcontinental railroad, a section of which is already in operation. This railroad starts from Jesselton on the west coast and runs to Tenom, 95 miles inland and which at present constitutes the terminus of the line. The expedition set out from the last-mentioned point and struck across the country toward Cowie Harbor on the east coast. The distance as the crow flies is 150 miles, but owing to the difficult nature of the country to be traversed, six months were occupied by the party to effect the crossing. The route lay through a vast primeval forest, through which

there did not exist even the barest trail, so that the party had to cut their way through the dense growth. It is stated that the extension of the railroad will not prove difficult from an engineering point of view, since the configuration of the country is not very broken, and probably the work of construction upon the remaining section will shortly be commenced. On arrival at Cowie Harbor the party at once set out upon a second expedition for the survey of a railroad from Sandakan northward to Murudu Bay, which will be approximately 300 miles in length, but owing to the fact that the country through which this line will extend is fairly well known, the survey will be enabled to carry out its work with greater facility and expedition.

THE NEW WIRELESS TELEGRAPH STATION AT NAUEN, GERMANY.*

By L. RAMAKERS.

ONE of the most serious inconveniences that have hitherto attended the operation of important stations for wireless telegraphy is due to the employment of wooden towers and masts, to which it is impossible to give strength and stiffness sufficient for all emergencies.

A great advance has been made by the Gesellschaft für Drahtlose Telegraphie of Berlin, which has devised a steel tower of such construction that no loss of current can result from vibrations of the support of the antenna. This novel arrangement, which includes also an antenna of improved construction, has been adopted for the central station for wireless telegraphy which was recently established by the German government at Nauen, about 25 miles from Berlin.

The installation comprises three principal parts: the tower, the antenna, and the operating rooms and apparatus. The tower is a steel skeleton of triangular section, measuring 100 meters (328 feet) in height and 4 meters (13 feet) in the length of each side of the triangle. It consists essentially of three vertical beams connected by diagonal tie-rods. Each beam is itself of skeleton construction, consisting of two plates connected by short diagonal braces, and is made in lengths of 8 meters (26 feet) which are bolted together. This construction continues from the top of the tower down to a level about 6 meters (20 feet) above the ground. Here the beams converge to a ball of cast steel which rests on a plate carefully insulated from the concrete foundation and supports the entire

FIG. 2.—DIAGRAM OF TOWER AND ANTENNA.

weight of the tower. At a height of 96 meters (315 feet) above the ground there is a platform from which it is easy to operate the three pairs of pulleys at the top of the tower by which the antenna is raised and lowered. At a height of 75 meters (246 feet) three anchor cables are attached to the tower to prevent its being overthrown or broken by the wind and to maintain it in a nearly vertical position—not exactly vertical, for the object of pivoting the tower on a steel ball is to allow it to yield to the wind by inclining 20 degrees or less from the vertical and thus lessen the danger of being overthrown. These cables are composed of round eye-bars connected by stout pins and run to three anchorages, each of which is 200 meters (656 feet) from the foot of the tower. The cables are insulated throughout their entire length. In consequence of the high electrical tension—sometimes corresponding to a sparking distance of 1 meter (39 inches)—which exists at their points of attachment to the tower it was necessary to employ a mode of insulation by which the cables are constantly bathed in oil. This method appears to have given excellent results. The anchorages are heavy masses of solid brickwork carried to a height of several yards above the ground.

FIG. 3.—APPARATUS FOR THE TRANSMISSION OF MESSAGES.

The attendant is adjusting the annular spark-gap. The tall Leyden jars are seen at the left hand, the transformers and inductance coils at the right of the picture.

FIG. 4.—APPARATUS FOR THE RECEPTION OF MESSAGES.

The antenna is shaped like an umbrella, the tower representing the rod. It is divided into six sections, which are so balanced in pairs over the pulleys mentioned above that the horizontal stresses are reduced to a minimum, and the resultant pressure is very nearly vertical. This arrangement, by the way, is patented. Each sector, however, can be detached and lowered separately.

The upper part of the antenna consists of 54 wire cables, nine in each of the six sectors, but at a point one-fourth its length from the ground each cable divides into three so that there are 162 cables at the bottom. To the bottom of each sector are attached two hempen ropes, which are insulated from the wires and are fastened to the ground by pegs at their lower ends. The aggregate surface of the antenna is about 60,000 square meters (646,000 square feet, or nearly 15 acres).

From the top of the tower the nine cables which compose each sector are continued in a parallel bundle to the bottom and thence to the operating room. These fifty-four cables are not insulated from the metallic frame of the tower, which is consequently a part of the antenna.

The ground contact is made through a system of 108 wires buried in the earth. These wires like those of the antenna divide as they diverge so that at the outer part of the system, which extends over 126,000 square meters (1,356,000 square feet, or about 31 acres) there are 324 wires. At the center the converging 108 wires are connected with the apparatus. The site of the station was determined by the unfailing abundance of subsoil water which assured a good "earth."

The operating rooms occupy a brick building which covers an area of 100 square meters (1,076 square feet), to which is annexed a garage for a locomobile. The ground floor contains the dynamo room, the transmitting office, and a workshop that may be used as a dormitory in emergencies. All the high tension apparatus is placed in the second story where it is better protected from dampness and hence more perfectly insulated. Another advantage of this arrangement is that the operator is less disturbed by the noise of the sparks. The building is heated by waste steam from the locomobile and lighted with incandescent alcohol lamps. The interior equipment comprises the source of power, and the apparatus for transmission and reception of messages. The power is furnished by a locomobile of 35 horse-power. The flywheel of the locomobile is connected by a belt with a monophase alternator coupled to an exciter on the same shaft.

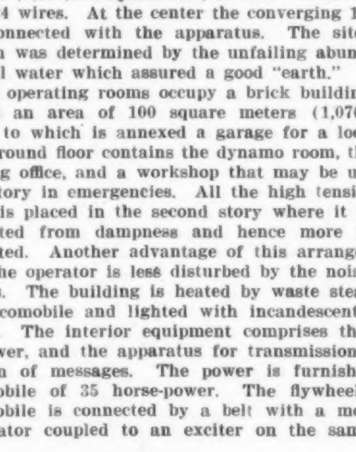


FIG. 5.—THE BASE OF THE TOWER.

The function of the board fence is to hide the secret of the method of insulation.

This generator, driven at the rate of 750 revolutions per minute, furnishes 25 kilowatts of electrical power in the form of a monophase current of 50 cycles per second. It contains a device which prevents the generation of a current of very high frequency.

Two cables connect the dynamo with the switchboard to which are attached a bipolar interrupter with

FIG 1.—GENERAL VIEW OF THE WIRELESS TELEGRAPH STATION AT NAUEN.

The dotted lines are the eye-bar staying cables. In the photograph the cables forming the antenna have been retouched. In reality they are almost invisible.

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

fusible plugs, a voltmeter, an amperemeter, an indicator of frequency and a transmitting and a cut-off relay. Four large inductance coils are intercalated in the dynamo current, in addition to the four transformers which produce the high tension transmitting currents.

The transmitting circuit includes a battery of 360 large Leyden jars, arranged three in series by 120 abreast, and having an aggregate capacity of 400,000 coulombs; an annular sparker without a blower, and an inductance coil composed of spirally-wound tubes of silvered copper, with binding posts by which the amount of inductance can be varied and connection made with earth and with the antenna. Two other inductance coils of high tension are intercalated in the charging circuit. The sparks are as thick as a man's arm, and their noise is deafening.

In consequence of the very exact unison or resonance which can be established between the dynamo and the transformers a comparatively small quantity of electrical energy is required to charge the transmitting circuit, notwithstanding its immense capacity.

To pass from the transmission to the reception of messages it is only necessary to move a lever which puts the receiving circuit into connection with the antenna and the "earth" and simultaneously shunts the transmitting current into the cut-off relay, thus preventing the possibility of accidental transmission and protecting the coherers and detectors, which are very sensitive instruments, from the violent action of the strong transmitting current.

All the receiving instruments are mounted on one table, at the back of which, on an inclined board, are placed the condensers, inductance coils, etc., which are employed in syntonizing messages coming from various sources. This arrangement gives the operator easy control of all the receiving apparatus. The instruments are so connected that messages can be received on Morse apparatus or by telephone or in both ways at once.

The following remarkable results have already been obtained at the Nauen station: Communication with the steamship "Bremen" at a distance of 2,400 kilometers (nearly 1,500 miles); telephonic reception of messages from St. Petersburg, distant 1,350 kilometers (840 miles); simultaneous telephonic and Morse reception of messages coming overland (and over a mountainous country for most of the way) from the Righi in Switzerland, a distance of 800 kilometers (nearly 500 miles).

THE CONDUCTIVITY OF AIR IN AN INTENSE ELECTRIC FIELD, AND THE SIEMENS OZONE GENERATOR.

In connection with the study of the electrical production of ozone, A. W. Ewell found it desirable to obtain some additional information regarding the electrical conductivity of air self-ionized in a strong electric field. One of the difficulties met with in such investigations is caused by the breaking down of the dielectric by the formation of a spark discharge. This is easily brought about as the breakdown potential is approached because of the difficulty of preventing discharges from taking place at the edges of the electrodes, or from small irregularities of the surface. This difficulty was got around by placing a sheet of glass, larger than the two electrodes, between them. The glass successfully prevented the formation of an arc. As the electrodes were heated considerably by the discharge, water jackets were placed behind them. To obtain a uniform field in the area studied, one electrode was made smaller than the other and surrounded by a guard ring insulated from it, but maintained at the same potential. The current through the section of area under investigation was read by measuring the fall of potential across a non-inductive resistance placed in series with it. Under the alternating difference of potential between the electrodes, displacement currents traversed air and glass, and when a certain difference of potential was exceeded, depending upon the distance between the electrodes, the air was ionized, and a conduction current was established in it. The displacement currents follow well-known laws, and it is the currents transported by the ions in the air and the electromotive force applied to the air which are of interest. The displacement current in the air is a quarter of a period in advance of the electromotive force, and the ionization current is in phase with the electromotive force. The current in the glass will be a displacement current equal to the vectorial sum of the two currents in the air. The results of a large number of observations are given, curves being plotted from the data thus obtained. These show that as the ionization current in the air increases, the electromotive force necessary to maintain the current decreases, and that as the current increases, the curves for different distances apart of the electrodes approach each other. The latter result may be explained by the compensation of the reduction of an electric force when the electrodes are separated by the increased volume in which the ionization occurs. The first result shows that when the current is increased beyond the values represented by the familiar lower portions of the curves, the air, under normal conditions, exhibits so-called negative resistance, which has hitherto been demonstrated only under the special conditions of high temperature and low pressure. Curves obtained for the power absorbed show that this does not increase proportionally with increasing distance or current, and is independent of the thickness of the glass. The effect of temperature was studied, and it was found that within the range available—from five to sixty-three degrees—it had little influence except upon the dielectric constant. Although an alternating electromotive force was employed for making the tests, the character of the wave could not affect qualitatively the main results, and the general conclusion is drawn that for air at ordinary temperature and pressure, as the current carried through the air by ions increases, the required electromotive force slowly increases to a maximum, and then decreases and tends to become independent of the thickness of air. For alternating electromotive forces of approximate sine form, quantitative results have thus been obtained which make possible the calculation of Siemens ozonizers.—The American Journal of Science.

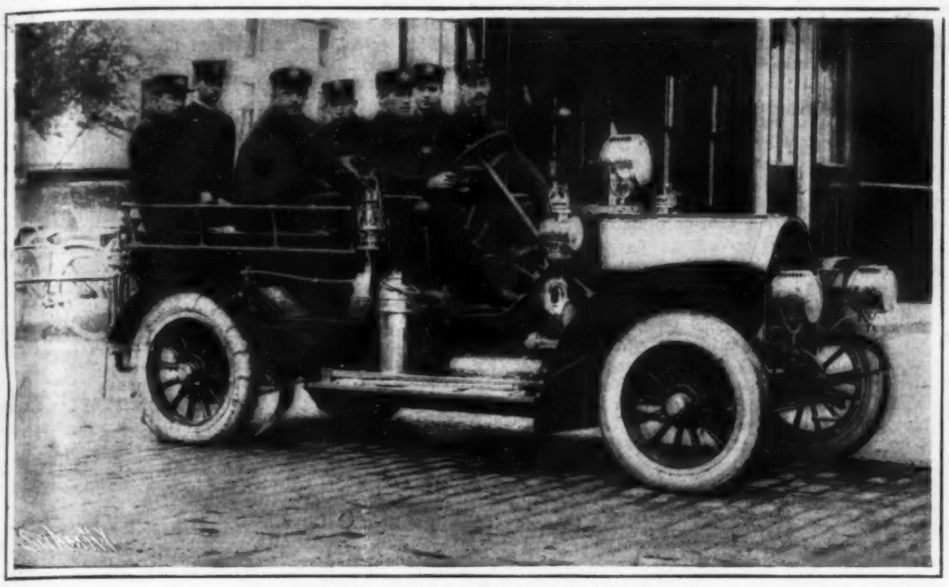
AN AUTOMOBILE EMERGENCY WAGON FOR FIRE DEPARTMENTS.

While the automobile has been used for the purpose of fighting fire in several forms, it has remained for Springfield, Mass., to put into operation the most novel machine of this type. The city authorities were finally impressed by the heads of the fire department with the necessity of adding more men to each station, the local insurance companies having contended that the force was inadequate for the fast-growing city. It remained then to choose between adding to the force of each station or of concentrating centrally a body of men equipped with modern means of locomotion and suitable apparatus for controlling incipient fires. To the credit of the department, it must be stated that the latter method was adopted, and the Knox Automobile Company, of Springfield, was invited to confer with the department chiefs and evolve a type of vehicle that would meet the emergency.

There were so many requirements that many consultations were necessary before the ultimate specifications were agreed upon. It was necessary that the automobile should carry at least eight men, some chemical tanks, a fair quantity of hose, and the usual quota of firemen's axes, hand spikes, etc. It was also essential that the machine should be ready for use at any moment, and capable of standing considerable exposure to the elements when on duty. This restricted the type of engine to that equipped with the direct means of cooling ordinarily known as "air-cooled," and as the Knox waterless system is admittedly the most perfect and efficient of its variety, proven by years of service, the details of the equipment for the work alone remained.

A wagonette style of body was chosen, the front or operator's seat being of the usual design, and carrying one other than the driver. The remaining seats are fitted longitudinally and carry three men on each side. The automobile is a Knox waterless, 4-cylinder, air-cooled. It is rated at 25 to 40 horse-power, with a wheel base of 112 inches. The entrance to the wagonette is naturally at the rear of the car, and at the back of the seats are brass hand rails, which are more than occasionally necessary when the car is making high speed. On each side of the front seat is fitted a chemical tank, fastened by an easily detachable clamp. The axes are carried on the side of the body, and the handspikes and crowbars on the running board. On the floor of the car is coiled 200 feet of regulation hose, and at the rear of the right side the necessary nozzle. Snap fastenings are also provided for carrying the firemen's helmets, while hand lanterns are suspended and fastened to brackets by the side of the operator. The car is equipped with the regular side oil and tail lights, two gas headlights, and a gas searchlight fastened to the dash, the latter three being supplied with gas from a supply carried in a compressed form in a steel tank on the right side of the car. In addition to the hand horn a siren is also provided, which is operated electrically. Weed chains are used on both rear wheels, while just forward of the latter is provided a sand box with two outlets, the outlets being controlled by the operator. This is rendered necessary from the fact that Springfield's streets are paved with wood blocks, and consequently, when coated with mud, are somewhat slippery. The eight men composing the crew were individually trained at the Knox factory in the use of the car, so that each may be called an expert.

The car is located at every station and answers every alarm, and its efficiency has been proved in a marked way many times since its inauguration. On the same day the car was delivered to the department—in fact, in less than two hours thereafter—it responded to an alarm only two blocks from an engine department; the emergency crew arrived at the scene of the fire and was at work before the engine arrived. It has been in service somewhat over a month, and the fire department and the city officials are so convinced of its merits that negotiations are pending for another car of like design, that one may



AN AUTOMOBILE EMERGENCY WAGON.

REAR VIEW OF THE AUTOMOBILE EMERGENCY WAGON.

attend downtown alarms and the other those on what is known as "The Hill," which is some distance from the downtown stations. The economy is best evidenced from the fact that twenty men were contemplated as an addition to the department, and it is admitted that the eight forming the auxiliary crew are far more efficient than the twenty could possibly have been, scattered among the widely-separated stations.

The car is painted a dark blue, tastefully striped with gold, the chassis being of a bright vermilion with similar decoration. On each side of the hood are the signs "S. F. D. Auxiliary Squad A."

The outfit has caused considerable comment, and it is a safe assertion that such machines will in the near future be considered a necessary component of every fire department that aspires to be considered modern.

VARIATION IN HORSE-POWER DEVELOPED BY AUTOMOBILE GAS ENGINES.

By A. E. Potter.

The purchaser of an automobile, no matter whether it is for pleasure or business purposes, or fitted with a four-cycle or two-cycle engine of the vertical or horizontal-opposed type, fixes in his mind the horse-power which he thinks he needs. There was a time not long ago when the salesman was able to convince the customer that the horse-power of the particular engine installed in the particular car which he offered, was considerably underrated, and that it would actually deliver almost any power in excess of its rating up to at least 50 per cent, but those days are past.

A 24—30, or 16—25 horse-power rating, on account of its unintelligibility, meant more to the prospective buyer than just 30 or 25, for these cabalistic figures could be translated, as no doubt many of our readers may have cause to remember, to mean that the engine had a maximum power of 30 or 25, with a minimum of respectively 24 or 16. The salesman in his anxiety to please the would-be owner, and to show his own knowledge of automobile mechanics, has been known to explain the double rating by claiming that the smaller number denoted the American or English horse-power, while the higher represented the French, Italian, German, or such other foreign standard as best suited his purpose.

The trend of manufacturers, as noted in the recent shows, to follow the single rating is laudable. They should have gone a step further and in each case added the number of revolutions per minute necessary to produce the rated horse-power, or the limit of speed at which increased power could be developed. This latter suggestion would no doubt bring dismay to many, if put into practice. If the horse-power rating were to be followed by the revolutions per minute, as for instance 24—1,400, or 35—1,200, it would be an innovation welcome to the buyer, and would be something tangible upon which to base horse-power calculations, knowing of course the bore and stroke, and the number of cylinders.

The power rating of any motor, no matter whether steam, gasoline, or electric, reciprocating as in the gasoline or ordinary steam engine, or rotary as exemplified in the electric dynamo or more modern steam turbine, is based upon its speed of rotation expressed in revolutions per minute. An engine, therefore, rated, as proposed above, at 24—1,400, would indicate that its rating of 24 horse-power should be developed at a speed of 1,400 R. P. M. In marine work where gasoline engines are designed for low, medium, and high speeds, this system could be profitably and safely employed by manufacturers, since their engines, mostly of the slow-speed type, adapted to the requirements of long, hard service, are of a class liable to be underrated. Manufacturers, on the other hand, of high-speed, delicately constructed, and usually over-rated engines, would no longer be able to impose upon purchasers in as bare-faced a manner as heretofore. A brake test, however, is the only way in which the purchaser can assure himself of the correctness of the manufacturer's claims.

Automobile engines are never of low, rarely of medium, and nearly always of high speed design, with their power rating consequently at such high speed, which is usually 1,200 to 1,600 R. P. M. As the tendency, as noted at the recent shows, is toward reduced speed and a more conservative rating, a manufacturer of a car using say a 24—1,200 engine would be given the preference over another with a 24—1,500, for the good and sufficient reason that the former would be manifestly a more powerful engine than the latter, because rated at a lower speed. Other conditions being equal, it should have a somewhat longer life than if run at the higher speed. This is more especially true with four-cycle than with two-cycle engines. As the majority of automobile engines are of the former type, and yet as the two-cycle engine is rapidly becoming recognized as an important power equipment especially for commercial cars, I will later consider the two-cycle with regard to those conditions encountered in its design and construction, which differ materially, both in theory and practice, from those met with in four-cycle construction.

While no doubt very many of our readers know what 1 horse-power means, there are some who have but a hazy idea of its definition in plain language. One would-be automobilist recently asked why it was necessary to use a 24-horse-power engine when a pair of horses would draw out of a ditch a car which its 24-horse-power engine would not budge. Another asked why a 4-horse-power engine would not be sufficient power for a doctor's runabout, quoting from Charles Haswell's well-known handbook: "As a horse can exert such a force (1 horse-power) but six hours a day, one machinery horse-power is equivalent to 4.4 horses." To both of these queries, what purported to be explanatory answers did not seem to be sufficiently complete to satisfy the questioners. It appeared to me that had the answers stated that if the gasoline automobile engine had the horse's slow-speed capability, much less power would suffice; that if the engine had been rated at a speed that could be readily transmitted to the wheels with sufficient reduction to move the car ahead as slowly as the horse would draw it, a lower speed rating and consequently horse-power developed, would have sufficed. If thus geared, as the car gained speed the engine speed would become excessive. In other words, the engine, as usually installed, develops a very small amount of power on the high gear except when running at high speed, as on level ground, and a very small portion of its rated power is applied directly in starting or in hill-climbing, unless a low gear be used. The horses, in drawing the car out of the ditch, exerted their maximum power at slow speed.

Sufficient power to lift, pull, or push 33,000 pounds 1 foot in 1 minute constitutes a horse-power. Conversely, the same power, in theory at least, would lift 1 pound 33,000 feet or 1,000 pounds 33 feet. From which 1 horse-power is said to represent 33,000 foot-pounds. While, as said before, the speed of rotation is always taken into account in horse-power calculations, in double-acting steam engines the number of revolutions is doubled in all computations, there being two impulses at each revolution. In single acting steam and two-cycle gasoline engines the revolutions and power impulses are the same. In four-cycle engines there is but one explosion at each alternate revolution in single cylinder engines; consequently the number of revolutions must be divided by two to get this correct factor for each cylinder. The other necessary dimensions and information in order to compute the horse-power are mean effective pressure, length of stroke, and area of the piston. The mean effective pressure is the mean or average pressure in pounds per square inch exerted against the piston during the power impulse. The length of the stroke is the proportional part of the lift expressed in feet, and is essential in reducing the calculations to foot-pounds. The area of the top of the piston, or rather the area of its cross-section, is the number of square inches upon which the mean effective pressure is exerted.

The well-known formula for estimating horse-power is $PLAN \div 33{,}000$, where $P =$ mean effective pressure, usually expressed M. E. P.; $L =$ length of the stroke in feet; $A =$ area of the piston; and $N =$ number of power impulses per minute. The product of $P \times L \times A \times N = X$ foot-pounds, which $\div$ 33,000 reduces this product to horse-power.

If all automobile or other explosive engines collectively, were to give the same M. E. P. at all speeds, it would be a comparatively easy problem to figure the horse-power which any engine should develop, by using the above formula, after first finding the M. E. P. at any number of R. P. M. If this were possible, an engine of four cylinders at 1,000 R. P. M. should develop four times as much power as at 250 R. P. M. The fallacy of thus figuring or computing horse-power is fully realized by manufacturers and engineers, for on the testing block practically no engine will ever show increased or decreased power in proportion to increased or decreased speed, except through a very small range. The average four-cycle automobile engine shows very little power at a speed of 250 R. P. M., with an increase of power out of all proportion to its speed, up to say 700 to 900 R. P. M., while the increase of power up to the limit of speed when such increase may be noticed, or when even decreased power results, varies greatly even in engines of the same make. As a case in point, the engine used in the Columbia car which established the record of 78 hours between Chicago and New York, as well as the one which reduced this record some 20 hours the year following, were selected because of the high power developed on test.

It would be very interesting to see plotted the developed horse-power and speed of many of our automobile engines, both American and foreign, and to note the rapidly advancing power curve from the minimum speed, up to where the curve becomes proportional to speed, and then increases less and less until it becomes practically straight, followed by a decrease or drop in power. Engine builders like to analyze these curves of other manufacturers, but are usually slow about producing records of duly attested results, which have been achieved under the watchful eye of the disinterested engineer of good repute.

The M. E. P. of gasoline automobile engines seems to be the crux of the situation. If an engine of four cylinders, 4-inch bore, and 5-inch stroke, at 1,500 R. P. M., were to develop 24 horse-power, the M. E. P. must be more than 50 pounds per square inch, and yet there were salesmen at the last show who glibly talked of 80 pounds M. E. P. Again an engine of four cylinders, 5-inch bore, and 5-inch stroke, at 1,200 revolutions, to develop 35 horse-power would have to show an M. E. P. of nearly 60 pounds. When the engineer comes to realize that rarely does an engine ever, even at its most favorable speed, exceed an M. E. P. of 67 pounds, his guaranteeing of horse-power at high speeds is done very carefully and cautiously. At a medium speed, say 600 to 700 R. P. M., it is quite an easy matter to so design and construct an engine as to get 67 pounds M. E. P., but when this speed is exceeded, it necessitates an altogether different timing of the spark, inlet, and exhaust valves, and possibly more area, and a different amount of lift to the valves as well, in order to reduce the amount of "wire drawing," or partial vacuum, produced by sharp turns in the inlet piping or carbureter.

As far as the power rating by the manufacturer is concerned, that is merely perfunctory. It may or it may not have been verified on the testing block, but other manufacturers of engines of the same bore and stroke may have adopted this rating, and so does he. He knows, and cares not, that his rating is purely guesswork; and if called to account, he points to his neighbor and claims his engines are just as powerful. That is all the satisfaction the purchaser or investigator gets.

For comparison I have taken the advertised bore and stroke of several four-cylinder automobile engines and their rated horse-power.

An engine 4½-inch bore and 5-inch stroke, rated at 45 horse-power, would have to show an M. E. P. of 67 pounds approximately at 1,875 R. P. M., 70 pounds at 1,800, and 84 pounds at 1,500. Another engine is rated at 45 horse-power, but is 5-inch bore and 5-inch stroke. This would mean an M. E. P. of 61 pounds at 1,500 R. P. M., or 70 pounds at 1,300. Again, an engine 4½-inch bore and 4¾-inch stroke, rated at 40 horse-power, necessitates an M. E. P. of 70 pounds at 1,500 R. P. M., or 81 pounds at 1,300. If a 28-horse-power engine has a bore of 4¼ inches and stroke of 4¾ inches, to develop its rated horse-power would take but 1,175 R. P. M. to show 70 pounds M. E. P., 1,300 with an M. E. P. of 63, and an M. E. P. of but 55 pounds at 1,500 R. P. M. The 5⅛-inch bore and 6-inch stroke engine rated at 50 horse-power must show an M. E. P. of 66 pounds at 1,500 R. P. M., or 70 pounds at 1,400. In the double-cylinder compound, if the so-called high pressure cylinders develop all the power, as is quite prevalently believed, bore 4½ inches, and stroke but 4 inches, with a 20-horse-power rating, the M. E. P. is alarmingly high, being 80 pounds at 1,700 R. P. M. and 91 pounds at 1,500. I have taken these advertised cylinder and stroke dimensions at random, and the natural inference is that some engineers or manufacturers are able to get much higher M. E. P. than others, or to develop their maximum power at a higher speed, else the engine ratings are made upon suspicion, as it were, with or without intent to deceive. Ignorance of the actual power delivered, or "doctored" results of the test, to justify extravagant claims made by designers and others interested, may likewise be responsible for variations in horse-power ratings. In some cases, though very rarely, the engine when tested is regularly equipped with expansion chamber and muffler, as in the completed car, while more likely anything that might possibly reduce the power from back pressure is carefully disconnected or entirely omitted.

While an intelligent, resourceful, honest, gasoline engineer, if allowed the opportunity and possessed of the requisite knowledge of theory and practice as applied to the gasoline engine, should be able to secure practically the same power results out of two four-cycle automobile engines, provided they were not so structurally designed as to make this impossible, securing anything like the same results from almost any two-cycle engines of the same bore and stroke at the same speed, is an entirely different matter. In the first place, while the two-cycle engine is a much simpler machine, has fewer parts, and develops more power in each cylinder for the same bore and stroke, it is subject to more causes of power variation than the four-cycle engine. The location, proportion, and arrangement of the ports can be widely varied. Slight leaks past the piston, imperfect bearings with leaks around the shaft, and many other little things combine to produce results which, even in the same engines, cannot be attained twice alike.

While the speed at which the four-cycle engine will produce the greatest M. E. P. may be 700, 800, or even 900, there are many two-cycle engines that will show a decided decrease after 450, and rarely will one be found that will show any increase of power above 750 R. P. M., except at a consumption of gasoline beyond all reason. One of the principal causes for this is found in the fact that at a speed of 750 R. P. M. the two-cycle engine has to take into each cylinder the same number of charges of gas, explode them, and get rid of the products of combustion, that the four-cycle does at 1,500 R. P. M. To overcome the inertia of the air and gasoline vapor, in the time allowed, is a difficult thing to accomplish, unless the exhaust ports open exceedingly early and thereby cause a large part of the effective power of the explosion to be lost. It also becomes necessary to open the inlet port correspondingly early to get the charge into the cylinder from the crank case. This gas, rushing in so much earlier, partly escapes through the early opened exhaust port.

The more we study the practical application of the two-cycle engine to the automobile, the more it seems as if the various conditions and the principles of mechanics combined, limit excessive high speed with correspondingly increased power. Whether or not this prophecy will be fulfilled remains to be seen, but unless some radical changes in construction and design are made I predict that the very best results with two-cycle engines will be obtained at a speed considerably less than 1,000 R. P. M.

With the adoption more generally of the two-cycle engine for automobile use, variation in horse-power in engines of the same bore and stroke, and at the same speed, will be decidedly more marked, harder to comprehend than is the case to-day in the rating of four-cycle automobile engines.

There are over 7,000 parts in a well-known 24-horse-power motor car.

THE FRATERNIZING OF THE GREAT NATIONS THROUGH SCIENCE.

The fraternity which exists among men of science the world over is a striking and gratifying fact. It is interesting to examine the causes of this phenomenon whose spirit it would be most desirable to extend to other spheres of life. Sir Michael Foster, the English physiologist, contributes an illuminating and suggestive article on the various phases of the subject to the Deutsche Revue, of which we find an interesting summary in the American Review of Reviews. Scientists, Sir Michael Foster reminds us, are perhaps the most cosmopolitan of men. They have, in varying degrees, been so ever since science began to lift its head, during the Renaissance period. In the sixteenth century, and for some time before and after, men of science, in spite of the dangers and difficulties of travel, wandered from country to country, great teachers of science filled foreign professorships, and students from all climes flocked to hear the masters of their particular branch. At that period the present nationalities of Europe were in process of formation; in the succeeding centuries, with a stricter delimitation of nations, this active intercourse of the disciples of science diminished in a measure. In the last part of the nineteenth century there was, on the contrary, a revival of the scientific *esprit de corps*, and one of the most marked traits of the life of to-day is the hearty appreciation with which every nation greets the scientific achievements of every other. No scientific society or academy considers itself complete until it counts eminent men of science of foreign lands among its members, and such institutions are as a rule glad to confer medals and other distinctions upon investigators of other countries. In the last twenty years, 1885 to 1905, the Royal Society of London conferred the Copley medal—distributed yearly, and the highest honor in its gift—twelve times out of the twenty upon men of science who were not British subjects.

This international community of scientists, fostered by academies and societies, is greatly furthered by the activity of the International Academic Associations, as well as by the work of the various international congresses of the special sciences. At present every branch of science holds a triennial conference which meets in many different countries, and which affords the members a chance of personal contact. International conferences are, of course, not limited to science, but it was science that inaugurated the beneficent meetings of the representatives of various nations. It may well be asked: Why is science so evidently cosmopolitan? "If we observe a man of science we find him as patriotic as any of his countrymen. He, too, thinks his own land, his people, his language, the best on earth. Neither is he averse to contest. His studies are particularly calculated to engage him in controversies, in which he shows himself as ready and stringent as another. How comes it then that this patriotic and combative individual is so excellent a member of the cosmopolitan union of science?" Several influences concur to bring this about. Every scientific worker is obliged to know what others who labor in his field in different lands are accomplishing. The researches of greatest import to him are carried on by men scattered over the whole civilized world. What these men do interests him far more than the multiform activity of his own countrymen, and there is, thus, an intellectual bond between them. He gladly seizes an opportunity to correspond with or meet them, that they may freely discuss questions which lie so close to his heart. Such acquaintance often ripens into the warmest friendship, and the ties of a common interest link them into a scientific brotherhood.

"Science, furthermore, demands that everything uttered in her name shall be 'the truth, the whole truth, and nothing but the truth,' as far as possible. It also, it is true, shares in the too great haste of the time. Scientific journals abound everywhere, and every scientist is exposed to the temptation of publishing in hot haste what he deems a discovery. Fortunately the scientific press has a safeguard which the daily press lacks. If an editor of the latter publishes a sensational article calculated to arouse ill-feeling between two nations, he is not specially blamed for not making sure of his data. It is part of an enterprising editor's duty to secure news of a stirring and exciting nature. It is different with the scientific press. If one is tempted to make known a new theory which lacks adequate foundation, it will soon break down; if he himself has not sufficiently probed it, others are ready to do so; thus it does not live long enough to do harm. Likewise a false criticism of others' work is soon disclosed and refuted. Luckily for science the tribunal of observation and experiment, before which every statement can be tried, is always at hand. Thus while the inaccurate and false reports of the daily press do so much toward disturbing the peace and harmony of nations, all such elements of discord are rendered harmless as quickly as they appear in the scientific papers, exerting little or no effect upon the fraternal bonds of the scientific world. The understanding between men of science is, fortunately, proof against any jealousy or discord from such a source as this." But the most potent influence that links men of science together is the consciousness that they all serve the *same* mistress; loyalty to her—to scientific truth—is for all the guiding principle of their intellectual life; and their common loyalty is the strongest of all the bonds which unite them. . . .

"The brotherly spirit of science is to-day an assured fact, and each succeeding year serves only to fortify and extend it. May we not regard this as a beneficent pledge of a more comprehensive brotherhood which is still to come?"

SOME FACTS ABOUT THE CARNEGIE INSTITUTE.

The Carnegie Institute at Pittsburg, Pa., was established originally by Mr. Andrew Carnegie some ten years ago as a library only, his purpose being to provide for the circulation of books through the large central building, with various branch buildings located at widely separated places in the city of Pittsburg. On the night of the dedication of the library, when no other thought than the reading of books had come into the minds of his auditors, Mr. Carnegie announced that he had determined to establish, in connection with the library, a department of fine arts, a natural history museum, and a school of music; and he straightway presented to his trustees $1,000,000 for these important developments. The income from that gift was judiciously used by the body of enthusiastic men chosen by Mr. Carnegie as his trustees, and so rapidly did the various departments grow that the time soon came when it was necessary to have a larger building. The library structure had cost about $1,000,000, and when the necessity of more ample space was explained to Mr. Carnegie, he authorized the whole building to be dismantled and a new one erected at a cost of $6,000,000. The Carnegie Institute, at the moment of its dedication, will represent a combined expenditure and endowment for all of its departments, including the Carnegie Technical Schools and the branch libraries, which occupy separate buildings, of nearly $20,000,000, probably a larger gift from one man to one community at one time than was ever before bestowed in the history of the world.

It is this new building with its imposing façade running four hundred feet at the front of Schenley Park and extending six hundred feet to the rear, costing $6,000,000 and worthy in its architecture to rank with the world's masterpieces, which is to be dedicated at Pittsburg on Thursday, April 11, 1907. It is the purpose of the trustees to arrange a celebration at that time which will be worthy of the extraordinary generosity which has created the Institute, and of the vast purposes which are to be developed through its future activities. An invitation to be the chief guest of honor has been extended to President Theodore Roosevelt, who has promised to consider the matter carefully, and who will attend if the exigencies of public business will permit. Besides the President, the trustees hope to secure the attendance of the members of the cabinet, the judges of the Supreme Court, distinguished senators and members of the House of Representatives, the foreign ambassadors and ministers residing in the United States, and officers representing the army and navy. Then those men and women who have won the most distinction in performing their share of the world's work will be invited, representing the achievements of science, art, literature, and statesmanship throughout the world. Particularly will men be welcome who have done most to advance the principles of peace by international arbitration as against the brutal arbitraments of war.

While a definite program has not yet been prepared, it may be said that the first day, Thursday, will probably be devoted to the addresses of President Roosevelt and Mr. Carnegie, prior to which the visiting guests will be given an opportunity of a private inspection of all departments of the Carnegie Institute. In the evening there will perhaps be a special recital by the Pittsburg Orchestra in Music Hall. It is intended that the second day shall be devoted to receiving addresses from kindred institutions throughout the world, and to the reading of papers and the discussions of great topics by those who come as strangers within the gates of our city. The third day, Saturday, will be devoted to excursions designed to show our visiting guests some of the great industrial establishments, the parks, and other attractive features of Pittsburg, and after that farewells will be spoken.

The Carnegie Institute comprises five great departments, the library, the museum, the art gallery, the music hall, and the technical schools.

The library now has a total collection of about 250,000 volumes, and even under the restricted conditions of building operations, which have hampered its administration during the past two or three years, it circulated 584,000 volumes among the people during the past year, and had an attendance in its various reading rooms aggregating 385,000, which is less than normal. It has a children's department through which fifty-four schools were supplied with all the books that were called for, while thirty-four home library clubs and thirty-five reading clubs were conducted under the auspices of the library, chiefly among the poorer children of the city. It has 153 agencies in the city of Pittsburg for the free distribution of its books. For five years it has maintained a school for children's librarians which is devoted exclusively to training young women for library work for the children. Students come to this department from various parts of our country, many of them being graduates of our best colleges. The demand for trained children's librarians is very great, and this work offers a new professional field for women with active and ambitious minds. All reports, catalogues and catalogue cards are printed in its own shops. Its branch libraries have been inaugurated with special ceremonies one by one, and those who visit them are impressed with their convenience and the cheerful home-like familiarity which they encourage toward books; with the pleasing nature of their architecture; with their commodious little auditoriums, so suitable for lectures and entertainments; and above all, by their possibilities in the way of culture and character.

Mr. Anderson H. Hopkins is the librarian, with a strong organization of nearly two hundred assistants.

The museum, already ranking as one of the four great museums of America, has had an exceedingly successful and well-proportioned growth. A purpose of scientific research has led it to send various exploring expeditions into different parts of the country, especially into the great middle West, where rich discoveries have been made in the field of paleontology, enlarging the boundaries of human knowledge. The Diplodocus, a monster eighty feet long, the most prominent example of this research, will be seen in the great hall of dinosaurs in the new building, surrounded by many other specimens of extinct animal life which inhabited the earth before the time of man.

The museum has a collection of 25,000 birds. In its department of entomology it has over a million specimens, more than 100,000 insects having been carefully mounted and classified during the past year. Its botanical collections are large and valuable. Its departments of mineralogy, zoology, ethnology, numismatics, ceramics, textiles, the graphic arts, and historical objects are most interesting and instructive. In its section of transportation it presents a series of beautiful models, showing the method of carrying men and materials from the earliest times down to the present days of palatial trains and steamers.

Dr. W. J. Holland is the director of the museum, and he is aided by a competent staff comprising about fifty expert men.

THE DEPARTMENT OF FINE ARTS.

In the art gallery there is held every year an international exhibition showing the best paintings of the world. The mark of authority is placed upon the merits of these exhibits through a system which is peculiar to this institution. When these exhibitions were first planned, the great question was: How shall we show to the world that the pictures accepted here are really worthy of regard, and that our prizes awarded in connection therewith are based upon a proper knowledge of painting? It was then decided that each painter of reputation who sent a picture to the Carnegie Institute for exhibition should be entitled to vote for eleven painters selected by himself from the entire body of artists throughout the world, and the eleven men receiving the highest number of such votes should be constituted a jury. This system brings annually to Pittsburg the greatest painters of Europe and America, who meet on a common ground and view all paintings, saying which shall be accepted and which rejected, and afterward what awards shall be made. The fairness, impartiality, and authority of this system have long been accepted by the world of painters.

The music hall has been truly a school of music. The Pittsburg Orchestra has completed its eleventh season successfully, performing the works of the great masters with an ever increasing degree of merit. Frederick Archer and Victor Herbert have been the conductors of the orchestra in the past. Emil Paur is now its conductor. The large organ is played twice every week before people who come without price and who listen to the best players.

Mr. George H. Wilson is the manager of the Pittsburg Orchestra and of the music hall.

When the new building is dedicated the new technical schools will not be quite two years old. Built on a site consisting of thirty-two acres, which was donated by the city of Pittsburg, these schools are rapidly growing in number and power and are now furnishing instruction to nearly one thousand pupils in the day and the night classes. More than seven thousand young men and young women have already applied for entrance to these schools, and it is hoped that in the future accommodation may be provided for all who thirst at the fountain of knowledge. As this enormous registration gives some indication of the public interest in technical education, it seems only proper to offer a very brief description of these schools for the further enlightenment of those who care to read of them.

The Carnegie Technical Schools embrace four distinct organic divisions, which together form a comprehensive system of technical education.

First is the school of applied science, which has been designed to administer to the needs of young men of sixteen years of age who desire a thorough preparation for some specialized vocation, such as architectural, civil, chemical, railroad motive power, foundry, electrical and mechanical practice.

Then there is the school of apprentices and journeymen, which offers a course of instruction for the further education of apprentices already at work at their trade, who will receive, at night or at such other times as can be suitably arranged, the technical and theoretical information which will prepare them for advancement to the ranks of skilled mechanics.

After that is the school of applied design, which offers courses of instruction to classes in technical design and mechanical processes of the various art industries.

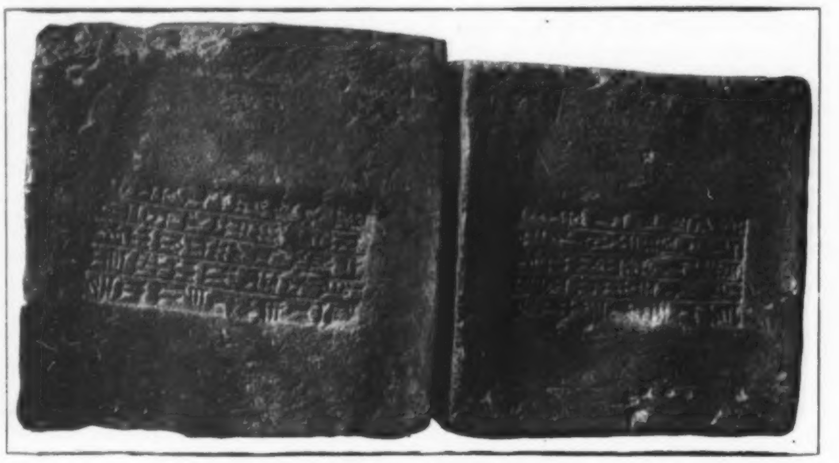
And last is the technical school for women, which has for its particular aim the training of women in many ways to earn their livelihood.

Mr. Arthur A. Hamerschlag, director, has been most fortunate in choosing a faculty which collectively stands upon a record of sound scholarship and achievement in the field of education.

EXCAVATIONS IN CHALDÆA.

By the Paris Correspondent of the SCIENTIFIC AMERICAN.

THE excavations which have been made on the site of the ancient city of Sirpourla throw considerable light upon the ancient Chaldæan art. The bas-relief and statues which were found here show that this art may be divided into three general periods, the primitive and archaic epoch, then a later period where we find a greater advance in the art, and finally an epoch of decline in which a graceful style predominates. The earliest Chaldæan sculpture has already been illustrated in a preceding article which relates to the period of King Ur-Nina, and shows the most ancient specimens. Quite another period is shown in the sculpture of the epoch of King Gudea, which dates about the thirtieth century, B. C., and which we illustrate here. These specimens come from the remains of an ancient palace which was uncovered not long ago. The palace was built of brick formed of clay and straw and cemented with a liquid clay mortar. There were no less than thirty-six different chambers, surrounding three inner courts. One part of the palace seems to have been the harem, and another part the men's quarters. Two kitchens with many vessels were also found. We expect to give a more detailed description of the palace in a succeeding article.



BRICKS FROM THE PALACE.

In the main court were found a number of statues representing King (or Viceroy) Gudea for the most part. These statues are all headless, but some separate heads have also been obtained. The only complete statue is the small one which we show here. It was found at a later period by the Cros expedition. In the statues of Gudea we have what may be called the second period of Chaldæan art, which has now advanced beyond the rude and archaic period and commences to work in stone with skill and confidence. Diorite of a dark green color is mostly used. It appears to come from Egypt or Sinai, as these names are found in the inscriptions. The style reminds us in some respects of the Egyptian, but differs from it in its originality, and indeed in many points it is quite opposed to the latter. We have a striking effect, but the statues are somewhat too massive in character. In spite of the great hardness of the stone, the flesh parts are well brought out, and in some cases are remarkable. The hands and feet show the smallest details, and are better worked out than in the Egyptian style. As to the attitude of the statues, we find the hands always clasped against the breast. Some of the statues are upright and others in a sitting posture. We also find the primitive form of the Assyrian costume consisting of a fringed square or rectangle of cloth. This is worn, however, without an under-tunic, as the latter is not yet employed and belongs to a later period. This garment is well indicated in the statues. A costume very similar to this was no doubt worn by the patriarchs in early Bible times, and the present statues are of great interest on this account.

The green diorite is harder than marble, but is easier to work than granite. It can be given a fine polish, as we find in many cases. No doubt the hardness of the material led to the choice of the present positions for the statues, as it required less work, and thus they became the conventional postures. Regarding the fringed square or shawl of wool, it seems to come from a remote antiquity. Herodotus speaks of the Babylonian cloak of fine white wool, but the Chaldæan cloak is seamless and woven in a single piece. It is draped in a characteristic manner, and somewhat resembles the present India scarf. The base of the statues is made quite massive and the feet are placed close together. In the seated figures the person is represented sitting upon a wooden seat which is somewhat low and of very simple form. The habit of engraving long inscriptions on the statue and seat is characteristic of Chaldæan and the later Assyrian art, and seems to show that the statues were designed to be placed in temples.

HEAD OF GUDEA.

Two of the large statues which were found in the court of the Palace represent Gudea in a sitting posture. He is shown here as an architect and designer of a fortified building. In the first of these statues, which is somewhat smaller than life-size, he bears upon his knees a large rectangular tablet. Lying upon it are shown a graduated scale and a drawing stylus for tracing the figures. In the inscriptions covering the lower part of the statue we find the cartouche of Gudea as the servant of the goddess Masip, and the inscription in 67 compartments is a consecration to the same divinity, and dedicating the statue to the temple of Ourou-Azagga, so that it is evident that the Chaldæan king took an active part in carrying out the work. The oblong tablet which measures some 8 by 13 inches seems to represent a plate of baked clay or stone covered with a thin layer of soft clay so that the design could be traced upon it by the point of the stylus. Here we have a very ancient drawing board, as well as the tools which were used. The stylus is a long-pointed instrument, either of wood or metal, and was flat on one side. It is remarkable to find the triangular scale, which is shown in relief upon the board, and it differs very little from our usual form of scale. The graduations, however, are different. The scale is about eleven inches long and is divided into sixteen equal parts on both the upper faces of the triangle. On one of the faces the graduation is quite distinct, and we find the units divided into fractions, these being in halves, thirds, quarters, fifths, and sixths. These are alternated with a full space or unit. On the other face we find two spaces divided in twelfths and eighteenths. The length of the scale represents one-half of the Babylonian cubit. Pliny mentions this cubit in speaking of the measurements of the walls of Babylon. In the present case it is reduced in size.

The second statue of Gudea, which is shown in one of the engravings, is quite similar to the former as to its general form. Here we have the same representation of the architect and his drawing-board, but in the present case the plan of the building has been drawn and the architect has now finished his design, seeming to offer the result of his labors to the divinity. The outline drawing shows the design of a fortified place. The triangular scale lies along the front of the board and the stylus along one side, the form of these instruments being the same as in the preceding case. The fortified place is one of considerable size and has a rectangular shape in general, containing six gates through the heavy walls. These gates are flanked by projecting towers in each case. The inscription on the second statue is a remarkable one, and as will be observed it covers the whole of the lower part of the figure along with the seat. In general, the inscription relates to the consecration of Gudea's statue in the temple of Nin-Gherson. This temple is often mentioned in the inscriptions of the present epoch, and appears to be one of the most important sanctuaries of this locality. The present inscription speaks of the countries whence came the materials used in building the temple, and also refers to a number of victories won by the king's armies, especially the taking of the Elamite city of An-Shan. In the present statue the seat is somewhat higher and the position is a better one. The head has been cut off by a chisel.

Fortunately, some of the heads belonging to the statues of this epoch have been recovered, but in this case it is the bodies which are missing, therefore we are not certain whether any of them belonged to King Gudea's statues. Of great interest is the head which

AN INSCRIBED CYLINDER.

ONLY COMPLETE STATUE OF GUDEA FOUND.

STATUE OF GUDEA.

we show here, bearing a kind of turban. Thus we find that this kind of head-dress dates from a period of remote antiquity and is one which has remained down to the present time. Herodotus says that the turban was part of the Babylonian costume. It may have been worn by all the people or only by the upper classes, such as the priests or officials. The present head, which is cut out of dark green diorite, like the statues, is very well executed and shows that the art of the period is already in an advanced stage. As to the style of the sculpture, we find it to be in many cases contrary both to the Egyptian and the Greek styles. Specially to be remarked is the method which is used of joining the eyebrows, and this is characteristic of the ancient Chaldæan style. It has been handed down to the Assyrian epoch, and even to modern Persia. The ornamentation which has been executed in relief in the present case seems to represent an embroidered stuff.

BRAIN WEIGHT AND INTELLIGENCE.

By Dr. J. Draeseke.

To the layman it would not appear to be difficult to prove the existence or non-existence of a relation between intelligence and brain weight. It would seem, for example, that the normal brain weight for each sex could be obtained by taking the average of a large number of individuals. But the brain grows in youth and loses weight in old age. Its weight is affected also by the manner of death. Death caused by hanging or drowning is accompanied by cerebral congestion, which increases the weight of the brain which, on the other hand, is diminished by severe internal or external hemorrhage. Finally, the brain after having been removed from the skull with the greatest care, must always be weighed in precisely the same manner, with the observance of many precautions against error.

After all of these difficulties have been surmounted the great question that presents itself is this: What is the normal brain weight at birth? According to Mies the average weight is 340 grammes (12 ounces) for male infants, and 330 grammes (11.6 ounces) for female infants, so that even at birth the male brain is 10 grammes (0.4 ounce) heavier than the female.

The same difference is found by Marchand, although his values for both sexes are higher than those of Mies. In the case of animals it is possible to compare the brain weights at birth of animals of different sexes in the same litter and here, too, the male brain is found to be heavier than the female. Another biologist claims to have detected differences in the convolutions of the brains of the male and the female fœtus at a very early stage of development.

This difference of 10 grammes (0.4 ounce) persists until the child has attained a height of about 70 centimeters (27.5 inches). Then the boy's brain begins to grow more rapidly than the girl's, so that the difference is increased. The first third of the increase in brain weight from birth to maturity is accomplished at the end of the eighth month, and the second third at the middle of the third year of life. Meanwhile, the mind of the child has been gradually developing. But in regard to these phenomena many problems still remain unsolved, and new ones are continually presented as the investigation becomes more thorough. For example, one investigator asserts, in contradiction of established opinion, that the surface of the brain with its numerous convolutions and furrows alters in structure for six months after birth. The fact discovered by Karplus, that the arrangement of the furrows may be inherited, is of importance in connection with the growth of the brain, for it appears to be almost certain that the inheritance is always from one, never from both parents. The growth of the brain is completed at the age of nineteen or twenty years in men, and between the sixteenth and the eighteenth year in women.

To the gradual increase in brain weight, accompanied by increase in mental power, in youth, corresponds a decrease in old age, during the sixth, seventh, and eighth decades. Hence we have to do chiefly with the weight of the brain in the third, fourth, and fifth decades. The values found by different investigators are discordant. From the values obtained by Marchand from material selected with great care I deduce an average weight of 1,400 grammes (49.3 ounces) for the male, and 1,275 grammes (44.9 ounces) for the female brain.

After obtaining these data we are prepared to consider the relation of brain weight to intelligence, or, more properly speaking, to higher intelligence. The existence of such a relation is asserted by some physiologists and denied by others. The section of Autopsy of the Anthropological Society of Paris was formed to decide this question, and in Goettingen Wagner was fortunate enough to be able to weigh the brains of the mathematicians Gauss and Dirichlet and other eminent men of science. Similar investigations were made by others, the results were collected and subjected to criticism, and so the material gradually became more extensive and more trustworthy. The largest of these tables, compiled by Spitzka, contains one hundred brains, and to it I have added eight more. If the weights are graded by increments of 100 grammes (3.5 ounces) the section between 1,400 and 1,500 grammes (49.3 and 52.8 ounces) is found to contain the greatest number. There are nearly as many between 1,500 and 1,600 grammes (52.8 and 56.3 ounces) and many between 1,600 and 1,700 grammes (56.2 and 59.8 ounces), but comparatively few between 1,700 and 1,800 grammes (59.8 and 63.4 ounces). Hence there can be no doubt that a relation exists between great brain weight and high intelligence. This fact is readily intelligible, for great activity of the brain almost presupposes the presence of a great number of brain cells. But still there remain cases in which great mental power and achievement have been associated with very low brain weight—lower even than the average brain weight of women. Explanations of these anomalies have been sought in age, height and other characteristics, but with only partial

SUNSPOT OF OCTOBER 17, 1905, 10 A. M.

success. Hence Retzius has very properly insisted that, in addition to the weight of the brain, its surface and internal structure must be thoroughly studied. It is also essential to know all about the great man's mental development in youth and the course of his subsequent life.

It is still more difficult to find a measure of the degree of intelligence. Hausemann divides famous men into four groups. The lowest group contains the minds that are greatly stimulated by alcohol, tea, and other drugs and by impressions derived from the senses; the second group comprises the "infant prodigies" whose intellectual powers wane in middle age; the third group includes pathological cases, usually terminating in insanity, and the fourth and highest group is that of the true geniuses whose powers remain unimpaired until old age. Spitzka has come to the conclusion that men eminent in exact sciences like as-

SUNSPOT OF OCTOBER 28, 1905, 10:45 A. M.

tronomy and mathematics have the greatest average brain weight. Next come the men of action, including statesmen and artists, and after these come the biologists, geologists, and other representatives of the descriptive sciences.

The problem of the relation between brain weight and intelligence becomes still more complex when the factors of race and nationality are introduced. Bischoff once asserted that the civilized races are distinguished from the primitive races by greater brain weight. It is extremely difficult to prove or disprove this statement, as in central Africa, for example, the determination of brain weights is made almost impossible by climatic and other causes, and in many lands the way of the investigator is blocked by inexorable funeral rites. The sparse data that have been collected are often discordant with each other and with the intellectual grade of the race in question, as shown by its history and state of culture. Taguchi has found that the Japanese brain grows more slowly than the European in childhood and youth but that the brain weight of the adult Japanese is equal to that of the European of equal stature and greater than that of other races of equal bodily dimensions. It will probably be found by further study that the size and weight of the brain, though important, are less so than the details of its structure. And only by the minute investigation of those details can we hope to reach any anatomical explanation of the intellectual performances of individuals or races.—Translated from Umschau.

THE DECLINE OF THE SUNSPOT MAXIMUM.*

By Rose O'Halloran.

The eruptions of unusual extent which appeared on the sun's surface from December, 1904, to the summer of 1905 were followed in the fall by displays of activity that completed a unique twelvemonth of spottedness. It was unique even compared with any one year of several past solar cycles.

Its two final months and the aftermath up to October 31, 1906, are the subject of the present record.

The remarkable eruption that transited the solar disk from the 13th to the 25th of October, 1905, was the eighth in a series of stupendous disturbances that commenced in the beginning of that year. A distinctly gray spot it was when central, for the numerous small umbræ strewn near the edges of a vast penumbra failed to convey the usual impression of blackness, though its branching form measured 100,000 miles in length and breadth. It was one of the largest that appeared during that year of giant sunstorms. Rapidly changing even in a few hours, the umbræ had increased in size and number, when on the west side of the disk more than sixty being scattered over its ash-colored tracts.

On the 24th of October a smaller discoloration, advancing from the foreshortened view, became likewise visible without the aid of the telescope. Two-thirds of the disk apart, but in the same heliographic latitude of fifteen degrees north, they differed widely in appearance and in amount of activity; the first, chiefly penumbral, irregular in outline and violently active, covered more than twice the area of the later arrival, which, with compact umbra central within an oval penumbra, was a typical black spot on the glowing surface and preserved remarkable stability during transit. Its main umbra, 36,000 miles long, to which visibility was due, has not been equaled in size for many years past; even the compact umbræ of the large group of September, 1898, not being comparable, as it was divided by bridges.

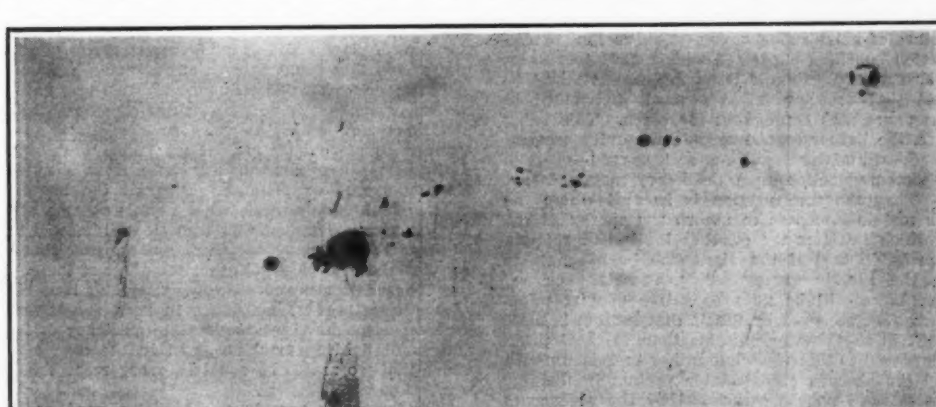
These two strongly-contrasted eruptions of October, 1905, had their beginnings as ordinary markings on the west side of the disk during the end of the previous month; but none of the numerous disturbances of November could be satisfactorily identified as a third appearance of either.

The continuance of activity in the northern hemisphere was shown, however, by a succession of eruptions during the first half of the month. Composed of groups of moderate size, it outlined a wavy stream from east to west in medium latitudes, but was a telescopic view until the tenth of the month, when the rear section was discernible to the naked eye. This streamy effect in sunspot distribution, which occurs from time to time, was also conspicuous (though on a lesser scale) in May, 1894, when the maximum of that period had commenced to wane. The south side of the October sun was not quiescent in the meantime, as occasional small groups invaded its placidity, and one of good size with streamy tendencies appeared at the end of November.

The following nine months, from December, 1905, to August, 1906, represented the average condition of maximum disturbance.

No doubt many groups came to view a second or third time by solar rotation, but the identification of two, from period, position, and general outline, was particularly satisfactory. Like two black streaks tipped with gray, one emerged inside the east limb on the 18th of March, and when central was found to be in north latitude fifteen degrees. With little change it crossed the disk, and on its return, when some degrees inside the east limb on the morning of April 15, its identity could be conjectured from aspect alone.

Early on the 18th, the day of the earthquake in San



STREAM OF SUNSPOTS, NOVEMBER 11, 1905, 10:30 A. M.

* Specially prepared for the Scientific American Supplement.

Francisco, it had advanced about one-fifth of the diameter from the limb, and when central three days afterward, though smoke, ashes, and unsteady air somewhat hindered observation, its latitude was ascertained, and the main sections were seen to be little altered but for the addition of a few small spots. Another, a large-sized single spot possessing much stability of form, first appeared on the 28th day of June, returned on the 25th of July, and though decreased in size, its general outline and position in the same northerly zones aided identification.

In an estimate of sizes, this spot, during its first transit, and also one that was central in the beginning of August, were the only eruptions visible to the average unaided eye during the above-mentioned nine months. Decreased activity was thus more noticeable in a comparison of areas than of numbers, insignificant disturbances far apart being frequent, as though spot-producing forces had ceased to act with concentration. A decline in size was still more marked in September and October, 1906, and on ten days, distributed toward the end of the latter month, not even the faintest penumbral marking was visible in a four-inch lens. Such prolonged intervals of unbroken whiteness have not been seen since September, 1903, when the minimum of spottedness was but one year past.

The predominance of activity in the northern spot zones, noticeable since the beginning of maximum, continued on an increased scale, only about four-ninths of the entire amount having appeared south of the solar equator during the period above described. The two final months show that quiescence has set in equally in both hemispheres.

Unless a revival ensues, forming a secondary season, as in 1883, the maximum of this sunspot cycle was more brief, its date more definite, and its intensity greater than the maxima of the two previous cycles.

GRAIN GOLAH AT BANKIPUR.

THE "golah," herewith illustrated was built for a granary in 1783, but has never been used for that purpose. It is 426 feet round at the base, with walls 12 feet 2 inches in thickness, the interior diameter being 109 feet; it is about 90 feet high, and might contain 137,000 tons. Inside is a most wonderful echo, best heard from the center of the building; as a whispering gallery, there is, perhaps, no such building in the world. The ascent to the top is outside by steps; at the top is a platform 10 feet 9 inches round, which has a stone placed in the center. This stone can be lifted, and access obtained to the interior. It is said that Jang Badahur, of Nipal, rode a pony up the steps outside to the top.—Country Life (London).

RADIUM AND GEOLOGY.

SOME discussion has been going on recently, due to the suggestion of R. J. Strutt that the data showing the radio-activity of the materials of the earth's crust would not only account for the heat radiated by the earth, but, if this radiated heat be actually due to the disintegration of radium, the latter substance must be confined to a comparatively thin layer at the surface. It is suggested by J. Joly that if a probable reason could be advanced why uranium should disintegrate more rapidly near the surface than at greater depths, there would be no need to limit the radium to a shallow layer, and that the difficulty of restricting the heavy element uranium to the surface would in this way be avoided. Such a reconciliation of observed facts with probabilities may be found in the view that the breaking-up of uranium is not wholly spontaneous, but is partly secondary in character; that disruption of an α particle from an unstable atom may precipitate the failure of neighboring atoms. This method of disintegration has been suggested with regard to radium by J. J. Thomson. Should it be the case it might be assumed that uranium is, in general, distributed in random aggregates throughout the earth. This being the case, the lighter constituents in the outer crust of the earth—aluminium, silicon, and oxygen—exert a lesser screening action than the heavy metals deeper down. Thus the conflagration is isolated where the heavier metals interpose to absorb the energy of the α ray which initiates the changes leading to radium. It is probable that if the disruption be adequate to reduce the kinetic energy below a certain critical amount, there will be no propagation of disruption. The mere fact observed by Strutt that radium is more abundant in the heavier silicates than in the lighter, is not opposed to this view, but rather in keeping with it; and the absence of detectable radium in metallic meteorites need not be occasioned by the absence of uranium, but by the slower breakdown of the latter. Cosmical effects of the greatest interest are involved in this controversy, therefore the question of how far radio-active effects are spontaneous deserves full investigation. If these be found dependent on the matrix and on concentration, entirely new considerations arise. It is not impossible, in the present meager state of our knowledge, that the penetrating radiations observed at the surface of the earth have to do with the genesis of radium from uranium, the failure of such rays to penetrate deep into the crust limiting the production.—Nature.

Generally speaking, it may be said that most of the ivory imported into Europe comes from Africa. Some is Asiatic, but much that is shipped from India is really African coming by way of Zanzibar and Mozambique to Bombay.

Correspondence.

WHY NOT TWO 10,000-TON "DREADNOUGHTS" INSTEAD OF A 20,000-TON "DREADNOUGHT"?

To the Editor of the SCIENTIFIC AMERICAN:

In the late issues of your valued paper I have read and taken much interest in your descriptions of the "Dreadnought" and new proposed battleship for the United States navy.

Although I am not a naval expert nor in any way connected with the navy, I venture to ask, is the building of the new 20,000-ton ship going to be the most efficient type of warship? Why not build two 10,000-ton ships instead of one 20,000-ton ship?

These 10,000-ton ships may be built exactly in the same style, equipped with same armor as to thickness, have the same speed, and gun efficiency of the two smaller vessels combined to equal the gun efficiency of the larger vessel. In other words, the smaller vessels are to be built in proportion to the larger in every respect.

Would not the two 10,000-ton ships of the same speed, equal resistance as to armor, and having guns of same efficiency as the larger vessel, be much more effective than the one 20,000-ton ship?

Compare the two ships in battle. Here are two ships fighting against one, and all equipped with the same size guns. The smaller vessels are just as capable of delivering a deadly and effective fire as the larger. In case the larger vessel is sunk everything is lost, and the chances are that the officers and crew of a thousand men or more would be lost. If one of the smaller vessels is sunk, the other is still afloat and ready for battle, and the loss would be only half as great as compared with the larger vessel.

As I understand it, in line of battle the ships of a fleet are usually arranged in a semicircle and approach the opposing fleet in that position. Take twenty 10,000-ton ships approaching ten 20,000-ton ships, the fleets being equal in every respect, could not the smaller ships, being greater in number, completely surround the larger vessels, and direct a deadly and effective fire on them or be much more than a match for them? In case of mines, the larger vessel having a greater draft would be more liable to strike one

GRAIN GOLAH AT BANKIPUR.

and be put out of action, thus adding to the great odds against them.

Would you consider a 20,000-ton ship more effective than two 10,000-ton ships on conditions named above? Is there any advantage in the steadiness of a 20,000-ton ship against that of the 10,000-ton ship in regard to gun fire when in action? After the recent battle in the Sea of Japan the English naval critics decided that a ship that could fight in any position is the ship to build; hence the "Dreadnought." In these days of modern warfare it is not the lashing of ships together and delivering broadsides into each other, it is the accurate firing and hitting the right spot that counts. Fighting in these days is anywhere from a mile to four or five miles distance. Fire all the broadside guns of both smaller and larger vessels at each other. The chances are the greater number of hits will take effect on the larger vessel. Is it not the case that the Japanese laid special stress that the effect of the opposing fire was greatly reduced, owing to their men being of small stature? I note that in your recent issues no comparison has been made as to efficiency of large and small fighting machines, and in the case named above the two are to be equal in every respect to the one.

"Are too many eggs in one basket a good proposition when it comes to fighting warships?"

GEORGE THOM.

Appleton, Wis., December 27, 1906.

THE EFFECT OF LIGHT ON BACTERIA.

THIS subject has been studied by many experimenters, but with discordant results. The radiation from the electric arc, for example, contains ultra-violet rays, most of which are stopped by glass. Hence glass containers for the bacteria are inadmissible. The most convenient of the few substances that freely transmit ultra-violet rays is quartz, which can easily be split into thin plates. It would be difficult if not impossible to construct a suitable vessel of such plates but they can be used as windows, as in the apparatus described below. Vessels of the new "quartz glass" (made by fusing quartz in iridium crucibles with the oxy-hydrogen flame) are extensively used, notwithstanding their very high price, in experiments on the action of light on bacteria. But the substitution of quartz for glass would be useless if the bacteria were immersed in a liquid that stops ultra-violet rays. This is the case with the media commonly employed for bacterial cultures, but bouillon diluted with water in the proportion of 1 to 1,000 transmits ultra-violet rays very well. Distilled water transmits them still better but it is fatal to many bacteria and hence cannot be used.

The apparatus employed consisted of a square glass jar with a lateral opening closed by a quartz window, which was filled with distilled water in which were immersed two quartz-glass tubes containing bacteria. One of these tubes was placed just behind the quartz window, the other was placed out of the path of the rays and was also protected by an envelope of sheet lead. This second tube was used to determine whether, in any experiment, the bacteria decreased in number independently of the action of light. The contents of the tubes were continuously stirred by streams of various gases to prevent the settling of the bacteria. The source of light was either an ordinary electric arc or a mercury vapor lamp with a quartz tube. The water in the outer vessel could be thoroughly stirred with the stirrer. Its temperature was given by a thermometer, and regulated by a cold water coil. These precautions were necessary because many bacteria are killed by a slight elevation of temperature and, also, because it was desired to determine the effect of temperature on the destruction of bacteria by light.

In the first series of experiments rather low temperatures (57 to 68 deg. F.) were employed. The bacteria included the germs of typhoid and Asiatic cholera, the *Bacterium coli* of the human intestine, the *Bacterium prodigiosus* or "miracle bacillus" (so called because the miracle of the bleeding host is said to be due to its red secretion) and others. Many experiments were made but the result was always the same. At these low temperatures the bacteria were killed only by the ultra-violet rays. The interposition of a thin sheet of glass entirely prevented their destruction. The phenomena were the same in an atmosphere of oxygen and one of pure hydrogen.

In order to obtain direct proof of the effect of ultra-violet rays alone the visible rays, in some experiments, were cut off by the interposition of a plate of the dark blue rock salt which is found occasionally in salt mines. A thick plate of this mineral stops the visible rays almost completely but transmits ultra-violet rays. In these experiments, therefore, the bacteria were in darkness yet they were killed by invisible rays. Hence it appears that bacteria can be killed by "light" in a space that is perfectly dark to our eyes.—Adapted from Dr. H. Thiele in Die Umschau.

PRODUCTION OF FUELS IN 1905.

COAL.

FOR the fourth time in the history of the United States the production of coal in 1905 reached a total of over 300,000,000 short tons, showing an actual output of 392,919,341 tons of 2,000 pounds, valued at $476,756,963. Of this total, the output of anthracite coal amounted to 69,339,152 long tons (equivalent to 77,659,850 short tons), which, as compared with the production of 65,318,490 long tons in 1904, was an increase of 4,020,662 long tons, or 6 per cent. The value of the anthracite coal at the mines in 1905 was $141,879,000, as against $138,974,020 in 1904.

The output of bituminous coal (which includes semi-anthracite and all semi-bituminous and lignite coals) amounted in 1905 to 315,259,491 short tons, valued at $334,877,963, as compared with 278,659,689 short tons, valued at $305,397,001, in 1904. The increase in the production of bituminous coal in 1905 over 1904 was therefore 36,599,802 short tons in quantity and $29,480,962 in value.

COKE.

The coke production of the United States in 1905, which included the output from 3,159 retort or by-product ovens, amounted to 32,231,129 short tons, as compared with 23,661,106 short tons in 1904. The increase in quantity in 1905 from 1904 was 8,570,023 short tons, or 36.22 per cent. The total value was $72,476,196, as against $46,144,941 in 1904, a gain of $26,331,255, or 57 per cent. The average price per ton in 1905 was $2.25 against $1.95 in 1904. The average output from the by-product ovens in 1905 was 1,158.8 tons per oven, against an average of 365.8 tons per oven from the beehive ovens.

GAS, COKE, TAR, AND AMMONIA.

The aggregate value of all the products obtained from the distillation of coal in gas works and retort ovens in 1905 was $56,684,972, as against $51,157,736 in 1904 and $47,830,600 in 1903.

NATURAL GAS.

The value of the natural gas produced in 1905 was $41,562,855, as compared with $38,496,760 in 1904, with $35,807,860 in 1903, with $30,867,863 in 1902, with $27,066,077 in 1901, and with $23,698,674 in 1900—a gain of about 8 per cent in 1905 over 1904.

PETROLEUM.

The total production of crude petroleum in the United States in 1905 was 134,717,580 barrels, as against 117,080,960 barrels in 1904, 100,461,337 barrels in 1903, 88,766,916 barrels in 1902, and 69,389,194 barrels in 1901, an increase of 17,636,620 barrels, or 15 per cent over the production of 1904, and of about 34 per cent over that of 1903.

The increase in 1904 came from Kansas and Indian Territory, and Oklahoma, Louisiana, Texas, California, Kentucky and Tennessee, and Illinois, in the order

named. In round numbers, the gains in 1905 over 1904 were as follows: Kansas and Indian Territory and Oklahoma, 6,395,000 barrels; Louisiana, 5,950,000 barrels; Texas, 5,890,000 barrels; Kentucky and Tennessee, 219,000 barrels; and Illinois 181,000 barrels. The largest decreases in production in 1905, as compared with 1904, were in Ohio, which showed a decrease of about 2,529,000 barrels; West Virginia, 1,066,000 barrels; Pennsylvania, 688,000 barrels; Indiana, 374,000 barrels; and Colorado, 125,000 barrels. It will be observed that the greatest gains were in the South and West, and that, relatively, the Appalachian field lost heavily.

The value of crude petroleum produced during 1905 was $84,157,399, or an average price of 62.47 cents a barrel, as against $101,175,455, or 86.41 cents a barrel in 1904, as against $94,694,050, or 94.26 cents a barrel in 1903.

ENGINEERING NOTES.

The variety of earlier forms of gas engines has now been reduced to two classes, (1) the double-acting tandem four-cycle engine, and (2) the double-acting two-cycle engine. The single-acting type of each is only applicable in the smaller sizes. Each type has its disadvantages and each its special field of application. The four-cycle is used for general power work and the two-cycle for blowing service, and wherever variable and low speeds are essential. There is a tendency toward the employment of higher speeds in large gas engines, in order to reduce the first cost also of the generator. Therefore, since the peculiar process of charging with an open exhaust limits the two-cycle engine to speeds of from 80 to 100 as a maximum, this type is at a disadvantage. It would lend itself better to the building of vertical engines. Vertical engines promise great savings in manufacture and of course in floor space. They must be developed in order to compete with steam turbines in space economy, and also for purposes of ship propulsion.

A Paris firm has recently brought out a new method for storing acetylene so as to compress a large supply of it in a small volume, and it can be conveniently used for lighting or with the acetylene blowpipe. "Dissolved acetylene," as it is called, is a solution of acetylene in acetone and the solution is contained in a porous body which has been saturated with it, which body is then stored in steel cylinders for use. The dissolving power of acetone for the gas is so high that it allows of storing 13 cubic feet of acetylene in the small cylinders, which are used for lighting automobile headlights. Such receptacles are formed of soft steel welded by the blowpipe, and the cylinder complete weighs about 16 pounds. At the top is a valve or stop-cock, but as the pressure of the gas which comes off is necessarily variable and besides is too high to be utilized directly upon the burners, a regulating expansion-valve of the proper design is placed between the stop-cock and the cylinder, and it furnishes the gas at a pressure which is quite constant. A pressure gage shows how much gas remains to be utilized in the cylinder. Another use of the acetylene method is for welding metals in cases where both pieces are of the same nature, such as happens in the electric welding process. By the use of the acetylene blowpipe, which is designed for the purpose, many advantages are claimed over the oxy-hydrogen blowpipe in this kind of work. Owing to the very high heat obtained it is possible to weld pieces weighing several tons, and with a relatively low expense for gas. As the work is carried out more rapidly, there is a saving in labor and the cost for the gas is said to be only one-half. The weight of an acetylene outfit for an equal heat production is but one-third of the oxy-hydrogen outfit and is quite portable. This is an important point in cases where the metal pieces are fixed, as in ship work, boilers, etc.

At the annual conference of the German Society for the Study of Shipbuilding recently, held at the Charlottenburg Technical High School, Vice-Admiral von Eickstadt announced that the results obtained during the prolonged trials with the cruiser "Lubeck," to ascertain the efficiency of the turbine in its application to naval purposes, are shortly to be published, and it is anticipated that the proceedings will be of widespread interest, since therein will be set side by side the comparative advantages and disadvantages of this type of prime mover. All the anticipations of the turbines have been fully realized, while the doubts expressed by naval engineers have also been justified. The "Lubeck" in the course of these experiments has been ranged beside the "Hamburg," which is the sister vessel, only equipped with cylindrical engines. As regards the stopping efficiency of the two means of propulsion, it was found that at the signal to stop the "Hamburg" in every case pulled up within a shorter distance, ranging from 150 to 160 meters, than the "Lubeck," while the former vessel also attained her maximum speed in a shorter space of time than the latter. The question of initial cost is also an important consideration, a set of turbines costing from 60 to 80 per cent more than a corresponding set of reciprocating engines. As a result of their experience, the German naval department is convinced that the Parsons system is not the most efficient for all-round working as required in naval practice, and they have expressed their willingness to consider any system in which the defects of the Parsons system may have been obviated. Vice-Admiral von Eickstadt stated that he had urged upon the German Admiralty the necessity of testing the turbine installations, not only upon cruisers but upon first-class battleships as well, but the dearth of available vessels for this purpose militated against such a course, and consequently this phase of practical test had to be left to Great Britain. The German naval department, however, proposes to equip two additional cruisers within the next year with turbines, if at all possible, though in this case two other systems will be tested.

Ships equipped with suction producers and engines have actually effected a reduction of coal consumption to one-third of that of steam ships. This fact, together with the reduction in space occupied by engines and coal bunkers, and the corresponding gain in cargo space and the elimination of smoke and smell, make the adoption of gas power of the greatest importance for vessels which are to possess the maximum radius of action combined with the minimum cost of operation. Therefore, builders and owners of canal barges, tug boats, yachts, etc., ought to devote their most careful attention to this new development. While there is little or no gain to be expected in bulk and weight of the engine power, the gas producer occupies only about one-third of the space of a water-tube boiler, or one-eighth of that of a Scotch marine boiler, the dimensions depending on the grade of coal burned. In a 7,000-ton cargo steamer fitted with gas power, the saving in cargo space effected was 13,000 cubic feet. The weight of a gas producer compared to that of a water-filled boiler of the type such as is installed in yachts and tug boats, is from one-fourth to one-fifth that of the latter. The amount of water needed for evaporation is about one-half pound per horse-power for a coal consumption of three-fourths pound. On a trial run a 70-horse-power gas tug consumed in ten hours 530 pounds of German anthracite against 1,820 pounds of steam coal used by the competing 75-horse-power steam tug. This economy so far effected is in the ratio 1 to 3.44 and is certainly encouraging enough to induce capitalists and engineers in this country to investigate this matter before foreign practice is getting too far ahead. For the propulsion of larger vessels, the double-acting vertical two-cycle engine is the most promising type to be adopted, since it gives steady and quiet motion with variable speed, quick starting under load, and almost instant reverse when compressed air is employed, such features being the indispensable requisites for successful operation on board ship. The Deutz Motor Works, of Cologne, Germany, who were the first to investigate the technical and commercial possibilities of gas ships, have fitted their suction gas system on eleven vessels, the power of the various engines ranging from 35 horse-power to 90 horse-power. Recently they built two flat-bottom barges of 240 tons for river traffic, equipped with engines of 100 horse-power, of which one is doing active service between Cologne, Antwerp, and Rotterdam.

TRADE NOTES AND FORMULÆ.

Starch Tincture for Giving a Brilliant Polish to Linen.—The portions of the linen which are to be starched are saturated with the tincture and ironed in the usual way. The linen will acquire a plastic stiffness without becoming brittle, and show a fine polish. 40 parts by weight of water, 15 parts borax, 4 parts crystallized Glauber's salt, 1 part Seignette salt, 1 part benzoin gum, 20 parts clear glycerine, 2½ parts French turpentine oil, 10 parts 86 per cent alcohol, 10 parts perfume. The solid constituents are dissolved in boiling water, stirred with the cooled glycerine, turpentine oil, alcohol, and perfume and poured into bottles. The tincture is used in the same way as other preparations of the kind. Rice starch is stirred in hot water and a small quantity of the tincture added.

Preservation of Butter.—1. (Appert's method.) Take fresh butter of the best quality, and press it through a clean cloth in order to make it as dry as possible. Then cut it into small pieces and pack closely into glass jars, leaving no vacant spaces. Close the jars with cork stoppers, seal hermetically, and fasten with wire in addition, put into cold water and heat to the boiling point. Butter thus treated will keep in a cool place for six months.

2. Another (Bréon's) method is to put fresh butter into tin cans, under a thin layer of water containing tartaric acid and sodium carbonate. Fill up the cans with the liquid, and solder on the covers.

3. (Pickled butter.) Wash the semi-salted butter thoroughly and spread out in a thin layer on a moist table. Work into it 60 grammes (6 parts by weight) of fine salt to each kilogramme (100 parts) of butter. Pack the butter into earthen jars and set in a cool place for a week; then, if there is any vacant space in the jar, fill it up with salt brine. If the butter is to be sent away, pour off the brine and put in a layer of dry salt. This salted butter has a good flavor and can be used for the table. Cut it out from the jar in horizontal pieces, smooth off the surface each time, and fill the space with brine.

4. (Melted butter.) Butter may be melted directly over the fire or in a water bath (*bain-marie*). In the first case, put it into a copper kettle and set over a clear, moderate fire. Any impurities will sink to the bottom, or rise to the top in froth. Stir slowly and skim off the froth as it forms. When no more rises, cool to 50 to 60 deg. C. (122 to 140 deg. F.) and pour into earthen jars with narrow necks. When the butter has hardened, put a layer of salt over the top and close tightly with paper. The best way of melting is in the water bath; that is, with the vessel containing the butter placed in another with boiling water. It is a good plan to strain the melted butter through a cloth. It will keep unchanged for a year, but is good only for cooking.

ELECTRICAL NOTES.

Perhaps the first serious attempt to produce a solid network storage cell with some provision for the electrolyte was by Niblett. His cell, in its original form, was, to all intents and purposes, of the Planté type. Each electrode consisted of a highly cellular mass of material, which filled the cell completely, and was claimed to be so constructed that it was capable of absorbing sufficient electrolyte within itself, and obviating the necessity for providing extra acid space as in the ordinary plate cell. The electrodes were separated merely by a thin, porous, inert partition. The cellular construction was arrived at in a very simple manner. Each electrode consisted of a number of small irregularly shaped pieces of lead, which were filled into the cell and then formed Planté style. These irregular pieces were made in an ingenious manner by dropping red-hot lead into water. The cell was not introduced without much opposition, although it by no means stands alone as an example of the solid network type in England and other countries.

Some time ago we described some successful experiments in wireless telephony by means of electric waves made by Herr E. Ruhmer, of Berlin. We are now informed that this experimenter has succeeded in obtaining a satisfactory transmission of speech through a distance of about 30 kilometers (18.6 miles). Instead of superposing microphone currents above the current which feeds the electric arc, the exciter winding of the operating dynamo was directly acted upon in a manner similar to that suggested in connection with the speaking arc. The oscillations in the intensity of electric waves thus obtained, corresponding with the words spoken into the microphone, were found to be far more intense than in the original arrangement. Even without using the Poulsen exciter, that is to say, without the use of a hydrogen atmosphere, results quite as favorable could be obtained with the aid of a novel exciter of undamped waves, which is said to be remarkable for its simplicity and absolute uniformity in working.

During the holiday season retail merchants, window dressers and others having to do with show-window displays in which artificial illumination forms a feature should exercise particular vigilance to prevent the danger of fire. Often cotton or other highly inflammable material is used to represent winter scenes or other decorations of like character, and particular pains should be taken to forestall the danger of a fire starting in this flimsy material. It is well to remember that considerable heat is radiated by an ordinary incandescent lamp, and in time it is possible that combustion may be caused from this source if the lamp and the cotton or other light material are in close proximity. A case is reported of a recent fire in Savannah, Ga., where a window dresser left a 32-candle-power lamp with no lamp guard in contact with a wax figure covered with light drapery. While fires of this character are usually extinguished with no great loss, yet they may be the cause of a serious conflagration. The requirements of the National Electrical Code are strict in this particular, and it is said that insurance companies are considering the advisability of denying liability on claims where the insured has not observed the conditions of his permit allowing the use of electricity. Therefore, it is wise to be particularly careful in arranging window displays at this season of the year.—Western Electrician.

In view of the interest just aroused by Prof. Korn's improved process for the telegraphic transmission of photographs, diagrams, handwriting, etc., it will be interesting to learn that an indirect process designed for the same purpose has just been brought out by a Berlin engineer, Mr. Emil Fortong. The greatest drawback in carrying out on a commercial scale any of the processes so far suggested, is the impossibility of using official telegraph lines for long-distance transmission. In case the necessary authorization were granted by the State, enormous sums would have to be paid for that. Most outfits so far designed have therefore remained expensive. Mr. Fortong, however, prefers using an indirect process, in which the apparatus of the sending and receiving stations respectively, so far from being connected by a telegraph line, are carried along independently of any circuit, in a hand box requiring the operation of only a few cells. Correspondents are free to move the apparatus to any desired place, as any telegraph station will be able to transmit what is called the "picture telegram" in the shape of an ordinary telegram consisting of figures or letters. This "picture telegram" is automatically converted into a picture by an electrical decomposing and recording apparatus. The photograph to be transmitted is inserted into this apparatus, which after about twenty minutes will give out a paper tape containing rows of perforated figures that correspond with the transmitted photograph, decomposed into rows of luminous points. These rows of figures, corresponding with a scale of a given number of luminous graduations, are next telegraphed from the nearest telegraph station to the receiving station in the shape of an ordinary ciphered telegram, and the receiver of the picture telegram or ciphered dispatch finally recombines the rows of luminous points of the transmitted photograph to a picture arranged in the same order by means of a copying and typing apparatus comprising keys analogous to those of a typewriter. The received figures having been typed in rows in their proper order, a magnified reproduction of the trans-

mitted photograph will be obtained after about thirty minutes. The transmitted photograph converted into a ciphered dispatch can thus be transmitted by any electrical process, that is telegraphically, telephonically, or even by wireless telegraphy or telephony, both across land and sea, and if desired from ships or balloons.

SCIENCE NOTES.

The most significant tendency which an observer of educational progress sees to-day is that of specialization. The time is fast approaching when it will be recognized that merely a general education, whether on classical or scientific lines, is not alone a suitable preparation for life. Not that culture is less desirable than formerly, rather it is more desirable, but above this general substructure must be placed a technical education which will give that special application to some calling which the coming age will demand. Colleges which devote their attention solely to general cultural training will become of less importance. The institutions now known by various titles of technical colleges, institutes of technology and polytechnic institutes, are the colleges of the twentieth century which will do most for their students, which will be in closest touch with the needs of civilization, which will provide at once the most cultural, the most rational and the most scientific instruction. These institutions, by whatsoever name designated, will be the important colleges of the future, because they will give that perfect unity of thought and action, that harmony of theory and practice, which the educational needs of the future demand.

M. Forel has made some researches regarding the ants which are found on the Himalayas. He finds fifty-two special forms, fifty-one Indo-Malaise and specially the fauna of India which mount to a greater or less height up the slopes, and ten species of palearctic fauna which inhabit specially the high regions of the western Himalayas, but which are also found in Europe and on the Swiss mountains. One fact is to be noted, that in the Swiss Alps, with one exception, all the ants which are found on the summits are also found in the plain, and this is the same for other countries. It is only the Himalaya chain which shows a very remarkable and special fauna. The difference between the fauna which come from the Alps and the special types found in the Himalayas is caused by the great cold for the most part. There is in fact a much greater difference between the tropical climate of India and that of the Himalayas than between the plains of Europe and the summit of the Alps, which explains why some of the European varieties can support the climate of the Himalayas without change, while the Indo-Malay fauna need a special adaptation.

Some of the products coming from the recent eruption of Vesuvius are described by A. Lacroix, in a paper which he read before the Académie des Sciences. In the course of the eruption, numerous fumerolles were opened up along the fissures which occurred near the border of the crater. When he observed them, on the third of May, they were in the acid phase and gave off an abundance of water vapor charged with hydrochloric and sulphurous acid. The heat in many points rose as high as 350 deg. C. As the gases came off through a layer of fine cinders, covering the lava and underlying scoria, it was difficult to approach the fumerolles. M. Lacroix succeeded in securing a collection of specimens and during the remaining months he added to these. The solid products which are most abundant in the fumerolles are those found in general in the eruptions of Vesuvius, and they consist of chlorides of iron, potassium, sodium, calcium, etc., which are not well separated, with the exception of erythrosiderite, which gives small rhombic crystals of an orange red color in the cooled-off portions. These chlorides are covered in places by realgar, which appears in two forms, either in vitreous crusts of a dark red color formed by fusion or in crystals which are met with only on the surface, at a lower heat. The sulphide of arsenic seems to be a rarity on Vesuvius. Covelli observed it after the eruption of 1822, and Breislak found it during the eruption of 1794. It is to be noted that in the few volcanic points where this mineral was found, such as at Pozzuoli or Vulcano, it appeared only in the crystalline state. This association of amorphous and crystallized realgar recalls what is found in a different class of ground, namely the coal strata of Central France which have many minerals in common with the volcanic fumerolles, but whose origin is quite different, and here the realgar seems to come from the heating and destruction of coal pyrites. Another mineral he found is sulphide of lead, which was not observed in any former eruption of Vesuvius. This galena covers two forms of rock, either intact scoria or partly decomposed scoria. In the first case, the galena crystals are very brilliant, but in the second they are dull and black. The cubical form is always found. Several other minerals which are formed at the same time sometimes accompany the galena, and he finds magnetite or mangeso-ferrite in small octahedric crystals, also hematite, pyrrhotite, the latter in plates of a bronze yellow color. Small crystals of pyrites are also found. He considers that the formation of the galena can be explained by the reaction of hydrogen sulphide upon the vapor of lead chloride, which Durocher used in the synthesis of this mineral. As to the other minerals mentioned above, they were no doubt formed by analogous reactions such as hydrogen sulphide or water vapor upon chloride of iron.

THE
Scientific American Supplement.
PUBLISHED WEEKLY.
Terms of Subscription, $5 a year.

Sent by mail, postage prepaid, to subscribers in any part of the United States or Canada. Six dollars a year, sent, prepaid, to any foreign country.

All the back numbers of THE SUPPLEMENT, from the commencement, January 1, 1876, can be had. Price, 10 cents each.

All the back volumes of THE SUPPLEMENT can likewise be supplied. Two volumes are issued yearly. Price of each volume, $2.50 stitched in paper, or $3.50 bound in stiff covers.

COMBINED RATES.—One copy of SCIENTIFIC AMERICAN and one copy of SCIENTIFIC AMERICAN SUPPLEMENT, one year, postpaid. $7.00.

A liberal discount to booksellers, news agents, and canvassers.

MUNN & CO., Publishers,
361 Broadway, New York, N. Y.

TABLE OF CONTENTS.